The Federal Plan for Meteorological Services And Supporting Research

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FISCAL YEAR 1974

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METEOROLOGICAL SERVICES
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The Federal Plan for Meteorological Services And Supporting Research

FEDERAL COORDINATOR FOR
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AND SUPPORTING RESEARCH

FISCAL YEAR 1974

U. S. Depository Copy

JUNE 1973
WASHINGTON, D.C.

Preface

This Federal Plan is the ninth in an annual series developed by the Federal Coordinator for Meteorological Services and Supporting Research in response to Section 304 of Public Law 87-843. This Plan focuses on the provision of meteorological services that will contribute to the public health, safety, and welfare and to the effective use of the environment. The highest priority is being given to additional efforts needed to observe, predict, and provide warnings on severe storms, such as hurricanes and tornadoes. Concurrently, ways and means of providing quality services through reprogramming of funds from lower priority efforts have been identified. New funding is being requested primarily to apply modern technology to maintain or improve services in the face of reductions in manpower. Recent technological advances involving computers, satellites, ocean buoys, automation of weather stations, remote sensing, and automated data handling techniques, highlighted in the first section, will make this possible.

The second section describes the Meteorological Services —Basic and Specialized—and the operational and research programs planned for fiscal year 1974. It provides information on Department of Commerce efforts to meet the requirements of other agencies. It also identifies service objectives and requirements and anlyzes the service systems' ability to fulfill expressed requirements.

Many specific objectives are based upon requirements submitted to the Department of Commerce by other Federal agencies, international interests, and the user public. Some objectives are set by discussion with users, user groups, and public surveys. A continuing effort by the Interdepartmental Committee for Meteorological Services (ICMS) identifies requirements for products and services as common to two or more Federal agencies. It then becomes a responsibility of the Department of Commerce, to the maximum extent practicable and permitted by law, to provide those services.

A number of problem areas have been identified for support to aviation activities, both civil and military, and for a more complete global network of data to improve basic analyses and forecasts. The Department of Commerce has examined these and has found some that are beyond the state of the art. For example, the need to provide slant range visibilities and low-level wind shear measurements at airports has not been met because the associated technology has not been developed. Other problem areas concerning safe aircraft operations are being resolved as technology develops and priorities permit. These include providing the aviation operators with current measurements of standard meteorological elements and runway visual ranges with a continuous updating of forecasts for these observations; clear air turbulence watch and forecasts; and improved forecasts of convective storms with their associated turbulence and hail. The problem of providing a more complete global network of data, through more upper air data in the Pacific and a worldwide profile of upper air data to 100,000 feet, is being solved to some degree with the developing satellite technology. Other advancements such as automatic weather stations to replace human endeavor and low-level sounding systems are being phased into the services programs. More details on the employment of these activities in the meterological services appear in other sections of this Plan.

The Meteorological Services and Operational Functions sections treat the changes in operational programs, such as observing weather, transmitting data, preparing forecasts, and disseminating information. The final section describes the meteorological satellite program. The last page contains a list of publications prepared, or in the process of preparation, by the Federal Coordinator for Meteorological Services and Supporting Research.

The principal work of coordinating weather activities and of preparing and maintaining the Federal Plan is performed by the interagency committees shown on the inside front cover. These committees and their subcommittees conduct systematic, continuous reviews of basic and specialized meteorological requirements, services, and supporting research according to guidelines set forth in the Office of Management and Budget Circular A-62.

C E Roache

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Federal Coordinator for
Meteorological Services and
Supporting Research

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The Application of Technology—Past, Present, and Future

INTRODUCTION

Technology has advanced at a dramatically accelerated rate over the past several years, bringing with it improved weather warnings and services. The future holds even greater promise, in observation, processing, and dissemination of weather information.

Several years ago, polar-orbiting research satellites demonstrated that they could provide vertical temperature and humidity profiles of the atmosphere; an operational system soon will be initiated. Geostationary research satellites performed so spectacularly in data collection and relay and near-continuous monitoring of storm tracks that the way has been paved for operational systems to strengthen warning capabilities even further. Fourth- and fifth-generation computers capable of accommodating advanced physical-mathematical atmospheric models have been devised, bringing new opportunities to heighten the range and scope of weather forecasts, including detailed, short-range storm and flood forecasts.

Following are a few examples of the application of new developments in technology and automation to the achievement of significant improvement in the Nation's weather warnings and other services.

SATELLITES

Polar-orbiting satellites have long provided routine global weather observations. With the successful launch of NOAA 2 in Ocotober 1972, this capability has been greatly expanded. Polar-orbiting satellites with new sensors now provide vertical temperature profiles, total water vapor content over clear ocean areas, and high horizontal resolution day and night cloud imagery.

The NASA Applications Technology Satellite, a research geostationary vehicle, provides cloud pictures over the western Atlantic and Gulf of Mexico at 25-minute intervals during daylight. A second such satellite provided similar coverage of the eastern Pacific during its operational lifetime. Time-lapse movies produced from these film sequences have demonstrated the feasibility of detecting movement and change in character of tropical disturbances. Storm system wind fields have also been derived from cloud motion observations. Information provided by these satellites from data-sparse tropical oceans has substantially improved the reliability and timeliness of hurricane warnings. In addition, satellite pictures are being used to detect the early stages of some severe local storm development by monitoring the growth of distinctive cloud patterns before storm activity can be detected by radar.

The outstanding success of these satellites and the broad use of the data have resulted in a NASA-NOAA program to provide a Geostationary Operational Environmental Satellite (GOES) system. A two-satellite configuration is expected to be fully operational by 1974. The GOES system, when fully implemented, will provide near-continuous coverage of the conterminous United States and adjacent ocean areas for detection and tracking of hurricanes and severe storms and for timely collection and relay of data from observing platforms and remote stations. Real-time support will be provided to specialized forecast centers responsible for timely issuances of warnings for hurricanes, tornadoes, floods, and severe local storms.

All of the data obtained from satellite systems are made available routinely to other nations and have proved extremely valuable to them. Additionally, special advisories are transmitted to nations likely to be affected by storms detected by satellite over data-sparse areas.

BUOYS

To get critical sea level information from data-sparse, storm-prone areas, three data-gathering buoys are being tested and evaluated, and are simultaneously supplying operationally useful environmental data. One has been very successful in supplying critical data from a point 150 miles east of Norfolk. A second, in the Gulf of Mexico, has been useful in keeping watch on storm development in the Gulf. The third, very recently deployed in the Gulf of Alaska, not only will aid in preparing storm advisories but also will provide data vital to support construction operations for the marine leg of the Trans-Alaskan Pipeline System. Other buoys, both drifting and moored, undergoing development will be deployed soon for field test and evaluation. The technological gains expected will be applied both to operational programs and scientific investigations. Scientific programs dependent on buoy technology have included the International Field Year of the Great Lakes, the Arctic Ice Dynamics Joint Experiment, and the Northern Pacific Experiment. The GARP Atlantic Tropical Experiment also anticipates their use.

AUTOMATED OBSERVATIONS

Automation makes possible the collection of data from remote areas and the conservation of manpower. Automatic meteorological observing stations have been designed to perform such repetitive human duties as reading basic meteorological instruments and transmitting data. A comparable system for remote unattended sites is under development. Additionally, special-purpose automated systems primarily for reporting rainfall, river stage information, and to alert for flash floods have been developed and a multiyear procurement and installation program started. These systems will be deployed as needed to insure the continuance of weather and hydrologic observations when Federal agencies close stations, reduce hours, or automate facilities now manually operated. Some systems are also being made capable of collecting data by GOES satellite.

Another development is the use of on-site minicomputers for processing upper air data from balloon-borne instruments, leading to better manpower use. The Next Generation Upper Air Sounding System (NEXAIR) under development will further automate the system and will replace aging equipment. Its use of existing navigational aids for determining wind speed and direction is expected to provide more accurate wind information.

Equipment and techniques are being developed for automating the use and interpretation of radar. An experiment is being conducted utilizing minicomputers and digital data processing techniques to improve the usefulness of radar information. This will provide the meteorologist and hydrologist with information permitting the intercomparison of information from adjacent radars and from satellites. The experiment has shown that the long-range radar with a digitizer/processor can quantitatively determine severe weather echoes and track them, providing valuable information on their expected movement. In addition, the capability to provide quantitative amounts and the areal extent of precipitation is being enhanced.

The Airborne Weather Reconnaissance System (AWRS), now under development by the Department of Defense, will provide an improved capability to meet requirements for meteorological data collection, processing, and transmission from reconnaissance aircraft. The AWRS is compatible with existing weather collection and data transmission systems. It is a completely integrated system of airborne sensors, with computer-generated display, and data processing subsystem, designed for installation in WC-130 aircraft.

REMOTE SENSING

Historically, environmental observers have used various forms of remote sensing; the measurement of temperature profiles in the atmosphere below a satellite is a good example. Greater detail than satellites provide is needed, particularly at the surface and in the troposphere. Sonic devices and frequency modulated continuous-wave radar devices, operating together, appear to have considerable potential for measuring the temperature, humidity, wind, and turbulence in the low levels of the atmosphere.

Microwave weather radars have long been used to provide crude estimates of precipitation rates, total precipitation, and the precipitation coverage over a wide area. Research to develop techniques for sharpening these estimates continues. Microwave Doppler radar has been used to determine the air motions associated with falling snow, rain from stratiform clouds, and thunderstorms. Devices such as lidar have been used successfully to measure visibility and cloud ceilings. Remote sensing of both temperature and water vapor may also be obtained by radiometric techniques. These techniques, together with new and improved air- and space-based remote sensing, offer a unique capability for taking a new look at the total atmosphere, permitting many essential measurements to be obtained more quickly and accurately.

COMPUTERS

Fourth-generation computers used at the primary processing centers will improve the fidelity of analyses and forecasts and expand the application of numerical forecast models to the entire globe. Model improvements are possible by making full use of the wealth of data generated by new technologies and more sophisticated techniques to simulate the complex processes of precipitation, solar and terrestrial radiation, friction, and air-sea interactions. More accurate forecasts are expected from computations with these improved models, especially in large-scale storms and heavy rains.

The introduction of fifth-generation computers will permit continued advances in the theoretical modeling of the coupling of the dynamic processes of the atmosphere and oceans. Also to be studied are the response of the atmosphere to seasonal variations in solar radiation; the dynamics of mesoscale phenomena, such as tropical disturbances; the consequences of alternative configurations of global observational systems; the range of predictability of midlatitude, large-scale storm systems; the coupling between midlatitude and tropical circulations; and the nature and extent of the interaction between the lower and upper atmosphere.

AUTOMATED FIELD OPERATIONS OF THE FUTURE

Hand-in-hand with application of these observing and processing technologies is the need for a mechanism to help the forecaster in assimilating and assembling weather information. The demands upon the forecaster's time are already such that only a small fraction of the information available to him can be logically applied. In addition, warnings and forecasts, once produced, must be disseminated to users in time to be useful. This requirement ranges from a very few minutes in the case of a tornado warning to several days for a major flood warning. For critical time-dependent actions, a highly automated high-speed weather service system is essential. Therefore, a comprehensive program linking the use of modern technology to field operations and services through automation is being developed.

Studies are now being made of the weather service system of the future. Features being considered include on-site mini-computers at operational field offices. These offices could be connected with the primary and specialized centers and with each other via a full duplex, voice grade, national digital circuit. This circuit could carry field data to the primary centers and primary center products to field offices.

It is envisioned that, as the national digital circuit data passes each of the operating nodes, the on-site mini-computer would select the data required for application within that particular forecast or service area and store the data electronically for future use. The contents of this data base would then be available on a high-speed request/reply basis to any operating position. The data could be displayed on TV-type monitors with hard copy available upon request. The mini-computer could also distribute and disseminate the products and information. All automated facilities within a forecast or service area, e.g., surface observations, radar, and upper air data acquisition functions, would have access to the mini-computer, including the data base. The mini-computer would also distribute and disseminate data. Development and implementation of this concept is projected to take several years. Extensive cooperation and coordination among the agencies involved will be required, but will lead to much improved meteorological services.

Summary of Fiscal Data

The following tables summarize fiscal information concerning meteorological expenditures of the Federal Government for meteorological services and supporting research. Only the research that has as its immediate objective the improvement of meteorological services is reported; activities integral to Federal programs in weather modification, water resources, and air-sea interaction are not within the purview of this Plan.

All FY 1974 fiscal data contained in this Plan are reflected in the President's budget and should be used for planning purposes only. The scheduling and implementation of these programs after FY 1974 are subject to additional analysis and further judgment.

The fiscal information[1] is presented by agency (table 1) and by service (table 2) and consists of FY 1973 data, planned activities for FY 1974, and the net differences for meteorological operations and for supporting research.

In FY 1974, supporting research programs amount to $68,603,000 representing about half the total Federal expenditures planned for meteorological research expected to be reported to the Interdepartmental Committee for Atmospheric Sciences of the Federal Council for Science and Technology. Supporting research costs for FY 1974 reflect a net decrease of $2,216,000. There are significant decreases in some programs. Among these, the Air Force anticipates completion of the development phase of the Airborne Weather Reconnaissance System for a reduction of $3,500,000.

To be consistent with other agencies, NASA is not reporting funding as it has in past years for spacecraft, controls, and subsystems not directly associated with meteorological research. This will also facilitate reporting in the future on multidisciplinary research observation-type spacecraft, such as Nimbus G, which will fly sensors not only for meteorology but also for pollution and oceanography. This new procedure accounts for the overall reduction in NASA satellite flight programs of approximately $24 million in FY 1972, $28 million in FY 1973, and $19 million in FY 1974. These differences will be apparent if compared with flight program funding totals in the FY 1973 plan.

With regard to funding differences between FY 1973 and FY 1974, the following are noted: (1) With the SMS A scheduled for flight in the second quarter of FY 1974, funding is reduced by almost $2.5 million in FY 1974; (2) the peak funding for sensor development for Nimbus F is in FY 1973 so that the level is reduced by almost $6.5 million in FY 1974; (3) TIROS N is in the early stages of development with a substantial increase of over $4 million for FY 1974; (4) the operational improvement program increased by $1 million; (5) GARP will also experience an increase in FY 1974, almost double the FY 1973 effort, to $6 million for (a) observing systems simulation experiment, (b) assimilation of asynoptic satellite data into numerical models, and (c) preparation for an early implementation of the data systems test; and (6) a new start approved at $9 million for FY 1974 for Nimbus G, a multidisciplinary spacecraft as previously indicated, will encompass meteorology, pollution, and oceanography.

The Environmental Protection Agency has redefined some programs so that more of its activities are included under supporting research for meteorology. This accounts for an approximate $6,500,000 increase in FY 1973 over that previously reported by EPA. The research programs of the other agencies are being continued at about the same level of funding.

In FY 1974, operational programs amount to $436,056,000. The funding change from FY 1973 to FY 1974 shows a net increase of $24,248,000. Many factors contribute. The DOD and DOT (Coast Guard) show significant reductions in personnel; attendant cost reductions, however, are more than offset by general pay raises. Significant program changes within the Department of Commerce are directed primarily toward providing a balanced program to improve the warning system and community preparedness activities. This funding includes about $1,900,000 for additional radars, $16,000,000 for increased satellite operations, $1,250,000 to purchase time on an upgraded computer at its NMC, and about $1,500,000 to improve the system for disseminating warning information to the public. In this connection, the NOAA Weather Wire Service is now reported under dissemination instead of communications. Offsetting some increases are program reductions brought by general budget restrictions; they include eliminating climatologists for the States at $1,218,000, reductions in support to the Air Pollution Control Meteorological Service, and limited reductions in upper air soundings in the Pacific. In a joint program, the DOC and DOT (Coast Guard) are phasing out all ocean stations, except Hotel, during FY 1974. Savings are expected to accrue starting in FY 1975.

The DOD is experiencing large reductions in personnel, which accounts primarily for the more than $4 million reduction in surface and upper air observations. This reduction is offset by increases in the tactical radar and satellite data processing programs and the approximately $6 million for modification of aircraft used in storm reconnaissance. The DOT's (FAA) increase of about $3.2 million in Aviation Meteorological Service stems primarily from adding 100 unmanned FSSs to the system. Other agencies reflect generally level funding in their operations programs.

Military funds are combined, where appropriate, with civilian funds to show the total Federal expenditure for each category of service. The Department of Defense, like the civilian agencies, funds Basic, Aviation, Marine, Space Operations, and Other Specialized Meteorological Services.

Table 3 shows the distribution of operational costs only, by agencies, between the United States and overseas areas. This table clearly illustrates the heavy investment in meteorological services required to meet military needs outside the conterminous States. Certain funds, such as those for weather reconnaissance and some contracts for missile range support, are included in the column headed "States" because funds are contracted for or reported by the parent unit within the United States, although the operations actually may be performed in overseas areas.

Table 4 shows the extent to which Federal agencies made use of each other's capabilities through the purchase of meteorological services and/or supporting research by interagency fund transfers in FY 1973.

Table 1.—Federal plan for meteorological operations and supporting research, by agency

[Thousands of dollars]

	Operations			Supporting research			Total		
Agency	FY 73	FY 74	Net difference	FY 73	FY 74	Net difference	FY 73	FY 74	Net difference
Agriculture	....	....	....	827	881	+54	827	881	+54
AEC	1,564	1,852	+288	675	680	+ 5	2,239	2,532	+293
Commerce	168,253	190,703	+22,450	4,817	4,917	+100	173,070	195,620	+22,550
Defense	184,359	184,863	+504	20,654	18,181	−2,473	205,013	203,044	−1,969
EPA	1,000	600	−400	8,530	8,430	−100	9,530	9,030	−500
NASA	1,725	1,779	+54	29,678	30,296	+618	31,403	32,075	+672
Transportation	(54,907)	(56,259)	(+1,352)	(5,638)	(5,218)	(−420)	(60,545)	(61,477)	(+932)
Coast Guard	10,609	9,412	−1,197	....	....	....	10,609	9,412	−1,197
FAA	44,298	46,847	+2,549	5,638	5,218	−420	49,936	52,065	+2,129
Total	411,808	436,056	+24,248	70,819	68,603	−2,216	482,627	504,659	+22,032

(The USCG will decommission 10 more vessels during FY 1974 for an additional prorated reduction of $3,960,000. This information was received too late to be included in the budget tables.)

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[1] Funds specified throughout this Plan represent the total obligational authority required for each year and are presented by Fiscal Year. Funds are given in thousands of dollars on all tables.

Table 2.—Federal plan for meteorological operations and supporting research, by service

[Thousands of dollars]

	Operations			Supporting research			Total		
Service	FY 73	FY 74	Net difference	FY 73	FY 74	Net difference	FY 73	FY 74	Net difference
Basic	197,443	218,332	+20,889	36,687	33,890	−2,797	234,130	252,222	+18,092
Aviation	147,783	151,587	+3,804	6,768	6,365	−403	154,551	157,952	+3,401
Marine	9,474	9,615	+141	811	1,163	+352	10,285	10,778	+493
Space operations	8,358	8,432	+74	2,027	1,829	−198	10,385	10,261	−124
Agriculture	1,155	1,155	0	827	881	+ 54	1,982	2,036	+54
General military	31,403	30,824	−579	14,399	15,245	+846	45,802	46,069	+267
Air pollution control	4,625	4,225	−400	8,625	8,550	−75	13,250	12,775	−475
Other specialized	11,567	11,886	+319	675	680	+5	12,242	12,566	+324
Total	411,808	436,056	+24,248	70,819	68,603	−2,216	482,627	504,659	+22,032

Table 3.—Distribution of operational costs, conterminous States and overseas, by agency

[Thousands of dollars]

Agency	FY 73		FY 74	
	States	Overseas	States	Overseas
Commerce	157,036	11,217	179,130	11,523
Defense	114,173	70,186	116,295	68,568
Transportation	(42,659)	(12,248)	(44,161)	(12,098)
Coast Guard	1,861	8,748	1,062	8,350
FAA	40,798	3,500	43,099	3,748
EPA	1,000	......	600	......
AEC	1,564	......	1,852	......
NASA	1,725	......	1,779	......
Total	318,157	93,651	343,817	92,189

Table 4.—Interagency fund transfers for meteorological operations and supporting research, fiscal year 1973

Agency		Funds [1]	
Transferred from	Transferred to	Operations	Research
FAA	Industry	14	.....
	Commerce	....	794
NASA	Commerce	1,249.1	.....
	DOD	39	.....
DOD	Commerce	930	35
	USCG	18	.....
	FAA	1	.....
	NASA	....	92
AEC	Commerce	1,231	625
Commerce	NASA	15,660	.....
EPA	Commerce	1,000	1,069

[1] Thousands of dollars.

Meteorological Services

INTRODUCTION

The Federal Government provides two types of meteorological services—Basic and Specialized. The Basic Meteorological Service meets public needs, fulfills requirements common to two or more agencies, and provides the foundation for disaster warnings and the Specialized Services. It is used by all Federal agencies. The Specialized Meteorological Services provide facilities, products, and distribution mechanisms to serve such specific groups as aviation, marine, space operations, agriculture, general military, and air pollution control.

In both, primary needs are for more service and more accurate and detailed forecasts.

A continually increasing demand for weather services has occurred over the past 20 years, and without doubt the trend will continue (fig. 1).

In 1955, the Departments of Defense and Commerce joined forces to exploit developing computer technology and organized the Joint Numerical Weather Prediction (JNWP) facility. There has been steady improvement in the forecast models during this period as meteorologists concentrated upon large-scale, medium-ranged systems. It now appears that further improvements in sea level forecasting will depend increasingly upon improving our understanding of smaller-scale, atmospheric systems. This is particularly applicable to forecasting phenomena such as precipitation, cloud cover, and wind gusts. The keys to further improvement are effective use of available and emerging technologies—satellites, remote ground-based sensors, advanced computers, and new models. Assimilating these techniques and technologies into the forecasting system will result in a significant improvement by the end of the decade.

Weather Disaster Impacts

In an average year, severe weather takes more than 600 American lives and causes staggering property damage. In such a year, the mainland will be assailed by eight tropical storms, 600 tornadoes, more than 600 damaging hailstorms, 800 severe local windstorms, and numerous winter storms. Hurricane Agnes in 1972 brought 118 deaths and a record $3.5 billion in damage. Tornadoes collectively caused more than a billion dollars' damage during the years 1965-69. In a single year, hailfalls cause more than $300 million in damage. Heavy snows and ice storms are responsible for millions of dollars in loss annually. Any of these destructive phenomena can cause severe additional loss through reduced employment and productivity.

The absolute need for an effective system to detect hazards and warn the public has long been apparent. Many lives can be saved and much loss averted through such a system. For several years, Federal agencies have jointly formulated operations plans for cooperative effort; the result has been the saving of life, productivity and, to some extent, property. However, outbreaks with the savagery of hurricane Agnes provide a constant reminder that the need for improvement is ever present.

The decrease in annual deaths can be credited to steady improvements in the warning system (table 5). It is estimated, from analyses of public response to warnings like those issued for the Lubbock, Tex., tornado of May 11, 1970, and the Mississippi Delta tornadoes of February 21, 1971, that several hundred lives a year are saved by the present system of tornado warnings and that as many or more are saved by warnings of hurricanes striking congested coastal areas.

Although the record indicates that warnings of disastrous weather events and public response to them have improved, the role of the Federal meteorological services in protecting the health, insuring the safety, preserving the welfare of the people, and contributing to the efficient use of the environment needs to be enhanced. An increasing concern is the rapid concentration of people in areas vulnerable to disastrous weather. A Federal Plan for Natural Disaster Warning and Preparedness is being developed. This Plan, covering most disasters of geophysical origin, will be responsive not only to the 1972 OEP Report to Congress on

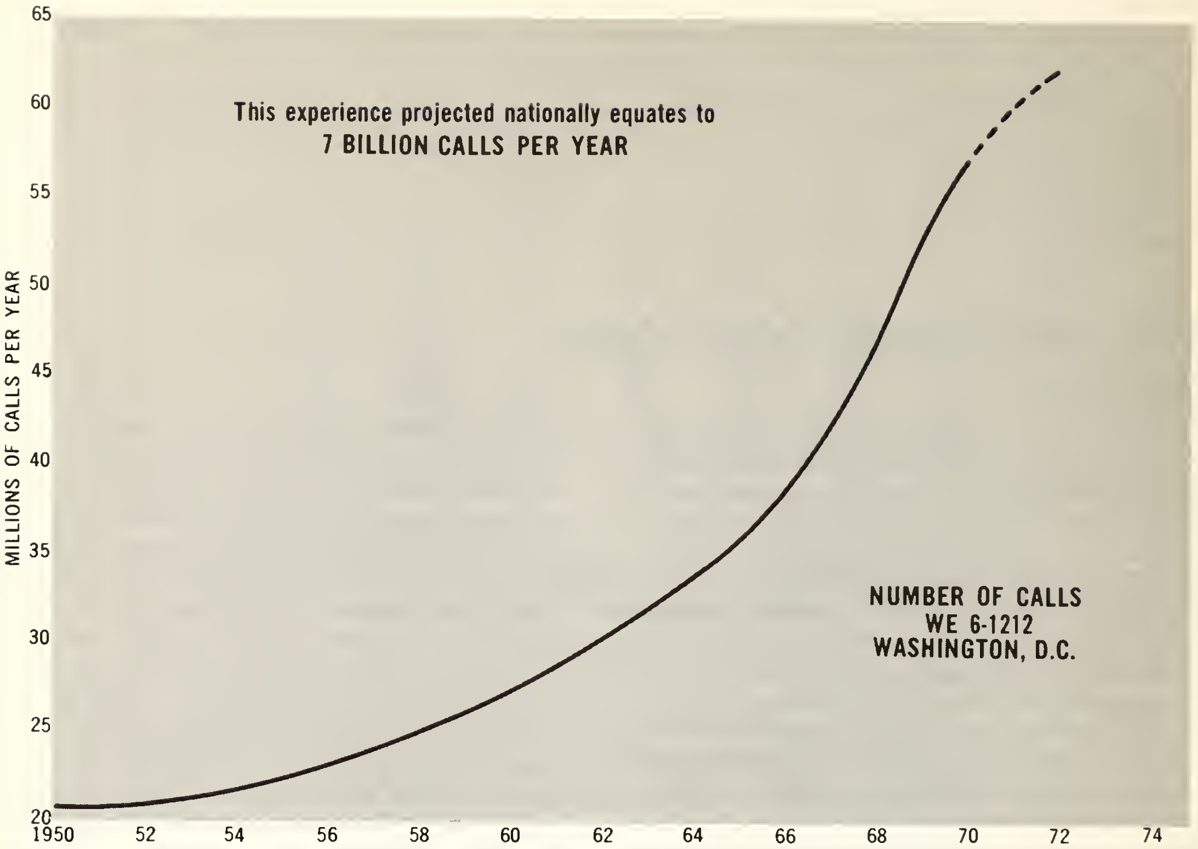

FIGURE 1.—Trend of increasing numbers of calls each year for weather information and forecasts from the automatic telephone answering service, WE 6-1212, Washington, D.C. Nineteen seventy-one and 1972 numbers were estimated after counters became overloaded.

Table 5.—Timely and accurate warnings plus effective preparedness activities do reduce deaths from natural disasters

Hurricanes		**Tornadoes**
Celia August 1971 30,000 evacuated 13 deaths	Timely and accurate warnings + community preparedness	Topeka June 8, 1966 17 deaths
Audrey June 1957 Little evacuation 526 deaths	Timely and accurate warnings only	Palm Sunday April 11, 1965 272 deaths
Galveston 1900 No preparation Deaths exceeded 6,000	No or poor warnings and preparedness	Tristate March 18, 1925 689 deaths

Disaster Preparedness but also to the 1973 Report on the Agnes Floods by the National Advisory Committee on Oceans and Atmosphere.

Goals and Requirements

In very broad terms, primary national goals for weather service to the Nation include:

- Protection of life and property
- Promotion of the Nation's welfare and economy
- Preservation and enhancement of the quality of the environment
- National security

However, weather service systems responsive to society's need for safety will also meet other social and economic requirements.

Many specific objectives are based upon requirements submitted to the Department of Commerce by other Federal agencies and the user public. In other cases, such as international aviation, requirements are set by the International Civil Aviation Organization and submitted through the World Meteorological Organization to member countries for adoption. Some objectives are set by discussion with users and user groups and by public surveys. When the requirements for products and services are identified by the Interdepartmental Committee for Meteorological Services (ICMS) as common to two or more Federal agencies, it becomes a responsibility of the Department of Commerce, to the maximum extent practicable and permitted by law, to provide them.

BASIC METEOROLOGICAL SERVICE

Description

The Basic Meteorological Service provides the fundamental observations and forecasts used by the general public, departments and agencies of the Federal Government, and many segments of the economy. The entire structure of the weather warning system rests on this foundation.

The Department of Commerce has the lead responsibility for this Service. Its basic observing networks, meteorological satellite system, communications networks, and analysis and forecast centers are supplemented by the following contributions of other agencies:

- Surface observations from the Department of Defense, Federal Aviation Administration (FAA), and U.S. Coast Guard stations in the United States and overseas areas.
- Upper air (balloon and rocket) observations from Defense and National Aeronautics and Space Administration (NASA) stations in the United States and overseas areas.
- Surface observations from Coast Guard Ocean Station Vessels (OSV).
- Weather radar observations from Defense, NASA, and FAA radars.
- Aircraft in-flight reports from civil and U.S. military aircraft worldwide.
- Winter and tropical storm reconnaissance by Defense aircraft.
- Climatic data from overseas areas.
- Satellite observations from NASA research and development spacecraft (e.g., Nimbus).
- Satellite observations from U.S. Air Force Data Acquisition Processing Program (DAPP).
- Typhoon warning services for the western North Pacific Ocean by the Defense Joint Typhoon Warning Center on Guam.
- High-speed data collection from overseas areas by Defense weather communication systems.
- Primary data collection and distribution in the United States by FAA teletypewriter systems.
- Marine forecast and warning distribution by Defense and Coast Guard radio facilities.

Four major weather-observing programs—surface, upper air, radar, and weather satellites—together with observations from other countries provide a base for the detection of potentially hazardous weather as well as the data base for fundamental analysis and forecasting.

Surface observations are made at fixed and mobile facilities on land and from ships at sea. In addition, a limited number of automatic weather stations and buoys are used for essential observations at unmanned or inaccessible locations on land and sea. An environmental buoy, EB-01, has been positioned in the Atlantic off the coast from Norfolk, Va., to support the National Weather Service in improving east coast winter storms and tropical cyclone forecasts. EB-03 has been positioned in the Pacific 185 miles southeast of Kodak Island, and EB-10 is located in the Gulf of Mexico.

The Basic Upper Air Observation Network (balloon) comprises Commerce facilities, with Defense and NASA participation at bases in the United States and overseas areas. Commerce funds the meteorological programs aboard the Coast Guard-operated OSVs (in support of international agreement) and Government moving ships and in the U.S. Trust Territory of the Pacific Islands. Because of specific U.S. needs the Coast Guard Cutter *GRESHAM* occupies Ocean Weather Station Hotel, 200 miles east-northeast of Norfolk, to provide weather data for the east coast winter storms and tropical cyclones forecast program. In addition to upper air, the *GRESHAM* provides synoptic surface and radar meteorological observations. The Basic Upper Air Observation Network is supplemented in data-sparse areas by Defense weather reconnaissance flights, the Defense and NASA rocketsonde network, and in-flight aviation information reports.

Defense provides special typhoon and hurricane reconnaissance in the Pacific and conducts hurricane reconnaissance missions in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. In addition, extratropical storm reconnaissance is flown in the western Atlantic and eastern Pacific during the winter season. Defense aircraft fly year-round weather and special storm reconnaissance missions over much of the ocean in the Northern Hemisphere and have a unique capability to fill partially the void of upper air data from the troposphere and lower stratosphere.

The Basic Weather Radar Network comprises specified Commerce and Defense radars. NASA participates by providing information from locations where its radars fulfill its own requirements. The FAA Air Traffic Control radars are also used in this Network to provide limited data in the mountainous areas of the western United States.

Weather satellites are the fourth of the Basic Meteorological Service's observational programs. The satellite program is discussed under "Weather Satellites." page 48.

Basic weather observations are collected and distributed principally by teletypewriter systems operated by FAA and NOAA. Weather charts prepared in basic analysis and forecast centers are distributed primarily to other centers and to local weather offices by means of the NOAA facsimile systems. Specialized weather communications systems, established to meet international and Defense requirements, contribute to the Basic Meteorological Service as high-speed data links with overseas sources.

Weather forecasts and warnings are prepared and then disseminated to the public through teletypewriter, telephone, and radio systems operated by NOAA and the Coast Guard and through mass media.

NOAA's National Meteorological Center (NMC), Suitland, Md., is the principal source for basic analyses and forecasts of the Basic Meteorological Service. NMC provides both manual and computerized analyses and forecasts for the Northern Hemisphere and for portions of the Southern Hemisphere. Its primary objectives are timely and accurate forecast guidance products to the Weather Service Forecast Offices of Commerce's National Weather Service, other Federal agencies, and industrial and commercial users. A continuing program incorporates new techniques and technology and, by automating the preparation and transmission of selected guidance products, enhances their utility. Emergency backup for NMC is provided by the Air Force Global Weather Central according to the *Federal Plan for Cooperative Backup Among Operational Processing Centers.*

The system is well designed to produce guidance products and forecasts of rather routine meteorological events required on a scheduled basis. These products reflect the state-of-the-art of meteorological services. Recent events, however, particularly the Black Hills flood and tropical storm Agnes, have highlighted needs not yet being met. There is an urgent need for central guidance between scheduled cycles in rapidly changing critical environmental situations. There are also needs for improvement in the central guidance products related to the forecasting of cloud cover and precipitation amounts. To support civil and military aircraft operations there is a continuing need for guidance forecasts concerning clear air turbulence, of convective storms and associated turbulence and hail, and of upper air conditions emphasizing the fine grain details between 30,000 and 45,000 feet in the midlatitudes.

Plans

To meet the needs for improved and expanded services, the following actions are under consideration and study:

Field Operations:

- Automate the sensing, acquisition, preprocessing, and delivery of the data basic to products and services.
- Automate the monitoring of existing and developing weather conditions.
- Automate the data handling (storage, retrieval, and display of raw data and intermediate products).

Observations:

- Procure local-use radars to replace obsolete WSR—1, 3, 4 and begin implementing a digitization system to enhance the use of WSR-57 radars.
- Begin procuring and installing next-generation upper air sounding equipment to replace aging equipment currently in operation.
- Procure automatic weather stations to maintain the integrity of the surface observing network by filling gaps and moving in behind other agencies which curtail or cease operations.
- Utilize buoys along coastal areas to complement other collection systems for providing warning and forecast information.
- Continue developing remote sensing techniques, and begin operation of some of the most promising toward the end of this planning period.

Table 6.—Basic Meteorological Service costs, by agency

[Thousands of dollars]

Agency	Operations FY 73	Operations FY 74	Supporting research FY 73	Supporting research FY 74	Total FY 73	Total FY 74
Commerce	144,605	167,055	4,389	4,489	148,994	171,544
Defense	(34,276)	(34,651)	(3,900)	(400)	(38,176)	(35,051)
Navy	12,041	12,295	400	400	12,441	12,695
Air Force	22,235	22,356	3,500	......	25,735	22,356
NASA	....	....	28,398	29,001	28,398	29,001
Transportation	(18,562)	(16,626)	......	......	(18,562)	(16,626)
Coast Guard	9,009	7,697	......	......	9,009	7,697
FAA	9,553	8,929	......	......	9,553	8,929
Total	197,443	218,332	36,687	33,890	234,130	252,222

- Phase out redundant collection systems where new technological advances can provide more cost-effective systems.

Present planning as reflected in the *Federal Plan for Meteorological Data from Satellites* calls for an improved operational sounder to be flown in the later 1970s on the NASA-funded TIROS N-type series. A prototype operational geostationary satellite, the Synchronous Meteorological Satellite (SMS A), is programmed to provide some data beginning in 1973. The addition of the SMS B will provide a fully operational two-satellite geostationary configuration before the end of 1974. Combined observational data from the Geostationary Operational Environmental Satellite (GOES) system, the polar-orbiting satellites (ITOS), and conventional weather observations will improve our ability to describe and diagnose the weather and to provide a more reliable service.

The *Computer Plan for Operational Forecasting and Atmospheric Modeling Research* states that a fifth-generation computer system is to become available for operational use by 1976. With the fourth- and fifth-generation computers it will be possible to use data obtained by the satellite in the operational global prediction models, thus providing a capability to predict more accurate weather changes for an extended period of time.

To integrate satellite and computer technology and modeling techniques, three interdependent tasks involving satellite data processing and reduction, data assimilation, and model test and evaluation were begun in FY 1973:

- *Satellite Data Processing and Reduction.* The plan is to develop a satellite data processing and reduction technique which involves the preparation of all data into a convenient digitized format for further reduction to a consistent data set for insertion into numerical models. An essential part of the reduction process is continuing the evaluation and intercomparison of the derived meteorological quantities to identify inaccuracies and inconsistencies in the data provided to numerical models. This task involves comparing wind and temperature fields obtained from independent sources, identifying significant differences and their causes, instituting improvements, and developing techniques needed for continuing quality control and evaluation of operational data.
- *Data Assimilation.* Federal activities are being directed toward more effectively reducing new environmental data from diverse sources and assimilating it into mathematical models, ultimately improving prediction. Atmospheric sounders on NOAA 2 and Nimbus 5 now provide measurements from which vertical temperature profiles and geopotential heights are derived for use in numerical weather forecasting. Higher resolution imagers (scanning radiometers sensing in the microwave as well as the visible and infrared spectra) are permitting more detailed analyses of clouds, snow and ice cover, and sea-surface temperatures. Other satellite systems collect environmental data from a variety of plaforms in remote locations from which needed data are not now available. These data sources and the more advanced computers now planned can support more complex and sophisticated mathematical models of the ocean-atmosphere system. In turn these will support the fulfillment of needs for better prediction of clear air turbulence, convective storms, and upper air conditions at altitudes of 30,000 to 45,000 feet and higher.
- *Model Test and Evaluation.* The plan is to begin developing new models consistent with increased computer power, with improved data coverage over the globe, and with the special characteristics of new observational systems—accuracy, reliability, and more or less random

distribution in time. This task will include testing and evaluation of new numerical models before the operational stage and during the model development stage.

The operations and research programs for FY 1974, described in the following paragraphs, are directed toward improvement in weather forecasts. Table 6 lists the costs of the Basic Meteorological Service, by agency, for FY 1973 and FY 1974.

Operational Program for Fiscal Year 1974

The Department of Commerce's increased effort in FY 1974 is designed to partially meet the most urgent of the requirements discussed previously in this Plan. Significant improvements include the following:

- Continue to automate the surface observing network where feasible and provide contract observers for other required sites.
- Expand the weather radar network to provide complete radar coverage with primary and local-use radars and provide additional remoting equipment to those forecast and warning offices without direct access to a radar.
- Effect major improvements in worldwide upper air data derived from the improved satellite sensors on NOAA 2, in collection and transmission of meteorological data and warning information by means of GOES, and in capability to display and use satellite information at forecast offices.
- Improve the central guidance products and services from the NMC to the forecast offices.
- Expand and improve the hazards warning services through improving and extending internal data collection and external dissemination systems and improving individual and community preparedness in the disaster-prone belts of the country.
- Effect more timely maintenance and replacement of facilities and equipment essential to the conduct of the service.

The Department of Defense is planning reductions in aerial weather reconnaissance operations. However, reconnaissance of hurricanes, typhoons, and east coast winter storms will not be impaired. The U.S. Coast Guard is disestablishing Ocean Station Echo with the resulting loss of surface and upper air observations from that location in the Atlantic. In this regard, all other Ocean Stations, with the exception of Hotel, are to be phased out by the end of FY 1974. It is anticipated that the soundings derived from the vertical temperature profile radiometer on NOAA 2 will offset this loss to some degree.

Research Program for Fiscal Year 1974

The Department of Commerce in FY 1974 will continue to stress development of techniques for objectively predicting all weather elements. On the larger scales and longer time periods, work is aimed at developing and implementing fully automated forecasts of amount of precipitation, probability of precipitation, amount of cloudiness, surface temperature, and surface wind at 254 U.S. cities for periods of 24-60 hours in advance. On the smaller scales and shorter time periods, work is directed toward a numerical model to predict precipitation on a space scale of 50 miles and on a time scale of 3 hours for projections up to 18 hours.

For the severe local storms observations and forecasting research program at the National Severe Storms Laboratory (NSSL), emphasis continues on the collection and analysis of severe storm data and the development of weather radar technology and computerized techniques to determine the motion, precipitation, and physical characteristics of severe thunderstorms. The objectives of the program follow:

(1) To design, install, and test network configuration and surface stations that can digitally record and telemeter the wind speed and direction in a form suitable for immediate mesoscale observation of the low-level airflow in the environs of severe storms;

(2) To provide accurate data fields of wind velocity, temperature, pressure, humidity, and rainfall in a form suitable for use in post-mesoscale synoptic analysis of severe-storm periods;

(3) To operate a tall meteorological tower and radio station for obtaining meteorological profiles of wind, temperature, and humidity in the lower and middle troposphere during severe-storm periods;

(4) To analyze severe-storm events, including hail, heavy rainfall, tornadoes, and strong wind gusts, and to relate them to quantitative weather radar data; and

(5) To develop techniques for the analysis, display, and tracking of severe-storm events that would lead to the improvement of severe thunderstorm warnings.

In FY 1974, the detailed design of the automated field system will be completed and work will begin on an implementation plan with emphasis on an overall strategy. Experiments with the Model Facility, implemented in FY 1973, will be expanded to include functions at the interface between the WSFO and users (both NWS and external). Specifications will be developed for automatic equipment suitable for field experiments. Additional interface hardware and software will be procured for NMC to provide a complete range of NMC products to be included in operational tests and experiments. Particular emphasis will be placed on reducing the number of personnel required to provide services at the same or higher level.

Major efforts in NOAA are devoted to developing families of modular automatic weather observing stations for use at (1) sites where communications, power, and maintenance are available, and (2) remote unmanned sites where maintenance is difficult and communications and power are generally unavailable. For use (1) the AMOS III-70 has been developed. In FY 1974, cloud and precipitation modules will be developed to enhance the capabilities of the AMOS III-70. For use (2) the Remote Automatic Meteorological Observing System (RAMOS I) has been developed. In FY 1974, modules for peak wind and communications and power options will be developed. A hostile environment wind sensor will be developed, tested, and evaluated. Additionally, a prototype "substation" capable of automatically recording climatological data in monthly increments will be developed, and test and evaluation begun.

Commerce will continue the Digitized/Radar Experiment (D/RADEX) during FY 1974. D/RADEX will be in a major iteration phase; technical applications will be modified as the result of experience gained during operations in FY 1973, and efforts will concentrate on completing a three-dimensional digitized radar capability. Plans will be prepared for testing of local-use radars. Capabilities of state-of-the-art radars will be evaluated, and their potential impact on NWS operations analyzed.

During FY 1974, all development, test, and evaluation on the Next Generation Upper Air Sounding System (NEXAIR) land-based high-altitude macro system will be completed. This new system based upon the use of Omega navigation aids is designed to satisfy the requirements for wind, temperature, pressure, and humidity data during the late 1970s. In 1974, major work will be initiated to develop mobile accessories, a low-density "safe" battery, and selected cost/performance improvements such as a new humidity sensor. Additionally, field experiments with a mobile van will be completed.

Results of a multiyear program to extend the acoustic echo-sounding capabilities of wind and temperature structure to tropospheric heights indicate that an acoustic sounding system can infer the general temperature structure and with considerable accuracy resolve the wind profile but not the atmospheric temperature profile in the lowest kilometer. A radio acoustic sounding system has produced excellent profiles of temperature to heights of 1.5 kilometers. Development of both systems will continue in FY 1974 with particular emphasis placed on exploring their potential for measuring humidity profiles. In FY 1974 a second Doppler radar will be placed into operation for remote measurements of velocity and precipitation fields, momentum fluxes, and turbulence spectra within severe convective storms. In addition, optical radars will be procured for the remote measurement of water vapor and temperature profiles in clear air. These devices will also be used for aerosol and air pollution measurements. Progress will continue on the construction and implementation of a steerable FM, continuous-wave radar system capable of using the small-scale humidity structure of the atmosphere as a tracer in studying the dynamics of clear air in the boundary layer. Developments in other remote sensing areas (Microwave Sounding System and Optical Cross-Correlation Sounding System) are being monitored, and investigation is continuing on electromagnetic signatures of tornadoes. Successful development of these remote sensing techniques will provide the basis for introducing operational systems that will begin to satisfy needs for observations in support of aircraft operations identified in the aviation section.

AVIATION METEOROLOGICAL SERVICE

Description

The Aviation Meteorological Service furnishes specialized weather information to pilots, dispatchers, air traffic controllers, and fixed base operators to promote safety and efficiency in civil and military aviation. Responsibility for the Service is shared among three Federal Departments—Commerce, Transportation, and Defense. The Department of Commerce provides meteorological services used by domestic and international civil aviation. The Department of Transportation makes recommendations to Commerce on civil aviation meteorological services, provides specialized equipment and surface observations at certain airfields, disseminates weather information to users, and distributes weather data over civil teletypewriter systems. The Department of Defense serves the global needs of military aviation and makes meteorological information from its weather reconnaissance and other facilities available to civil aviation.

Specialized surface observations, primarily in support of aviation, are made at approximately 522 civil and military locations in the United States. On the civil side Commerce provides these observations at eight locations and the FAA at 347 locations. The remainder are provided by Defense. These figures do not include cooperative observations by private operators at many smaller airports and the many observations operated in support of the Basic

Meteorological Service. At many locations the surface observation program is coordinated between Commerce and FAA or Commerce and one of the Defense agencies.

Analyses and forecasts for aviation are prepared by weather centrals, weather forecast offices, and weather service offices. Commerce operates 42 Weather Service Forecast Offices (WSFO) in the United States in support of domestic aviation; Defense operates four primary centers, 10 area centers, and three specialized centers in the United States in support of military requirements. These centralized facilities provide areawide guidance and forecasts for use by local weather offices and by briefing facilities at the terminals. Forty-two NOAA WSFOs (this includes San Juan) prepare detailed local forecasts for over 400 terminals on a scheduled basis, and six NOAA WSFOs provide forecasts for international civil aviation according to procedures recommended by the International Civil Aviation Organization for the North Pacific, North Atlantic, and Caribbean areas and Central America and West Europe. Ten Defense weather service offices also support international civil aviation in the interest of efficiency and economy. Cooperative Federal programs are conducted at the National Meteorological Center (NMC) of NOAA and at the Fleet Weather Central at Pearl Harbor, Hawaii. Private industries obtain meteorological products from the NMC over computer-to-computer links at no cost to the Federal Government for computerized flight planning. Specialized Defense units prepare computer flight plans —an average of more than 1,200 routes daily—in support of worldwide tactical and strategic military aircraft movements.

Weather observations and other information in support of domestic civil aviation are collected and distributed over the FAA teletypewriter Service A and over the Basic Meteorological Service teletypewriter systems. Defense agencies use the Continental United States Meteorological (COMET) teletypewriter system to meet the needs of military aviation and ground units in the United States. Aviation meteorological data and information are exchanged internationally on the Aeronautical Fixed Telecommunications Network (AFTN) teletypewriter systems operated by FAA and on the high-speed systems of the Basic Meteorological Service. The Automated Weather Network (AWN) of Defense provides for high-speed collection of data from overseas to meet Defense aviation and other military requirements; data from this system are provided to the NMC. The NMC places certain North American data on the AWN for distribution to military users.

Analysis and forecast centers distribute specialized weather charts for aviation purposes to local weather offices and briefing facilities—Weather Service Offices (WSO), WSFOs, and Flight Service Stations (FSS)—over the National and Aviation Facsimile Networks of Commerce. The Strategic Facsimile Circuit of Defense meets that Department's additional specialized requirements.

Voice communications systems are used widely in the Aviation Meteorological Service. The air-ground radio systems of FAA are used to provide weather information to and obtain data from pilots. Weather observations, forecasts, and advisories are carried as scheduled broadcasts on over 800 air navigation aids and as continuous transcribed weather broadcasts for 105 radio outlets. The Pilots Automatic Telephone Weather Answering Service (PATWAS) provides forecasts covering a 250-mile radius at over 53 locations, plus 10 additional locations that cover the local areas only. The FAA has a telephone network linking airports that do not have a local weather briefing outlet to a nearby FSS. Pilots use this network to file flight plans and to obtain preflight weather briefings. Airborne pilots can receive a weather briefing by radio contact with an FSS. The Department of Defense operates a network of air-ground radio stations for direct pilot-to-forecaster contact to provide observations, forecasts, and warnings on request to airborne military pilots and to obtain in-flight weather reports from military aircraft.

Aviation weather briefings by the Department of Commerce and by FAA are available to pilots through approximately 641 manned and by remote controls at 169 unmanned facilities. At the air terminals where a NOAA-WSO and an FAA-FSS are collocated, FSS personnel primarily handle the routine weather briefings. Users requiring more technical meteorological assistance are referred to the NOAA WSO. The FAA has instituted a new service from four FSSs along the west coast which provides current weather conditions for flight information. This service, designated En Route Flight Advisory Service, receives and disseminates numerous pilot weather reports. Because of the success of this initial program, FAA plans to expand the service to cover all the conterminous States. The FAA provides over 13 million pilot weather briefings annually, and NOAA about 2 million. Defense prepares detailed flight weather briefings at some 220 worldwide terminals and approximately 2 million flight briefings annually.

The objective of the Aviation Weather Service over the next 10 years is to meet international needs for upper wind and temperature forecast within agreed accuracy limits and provide and update critical terminal forecasts and other information for an

Table 7.—Aviation Meteorological Service costs, by agency

[Thousands of dollars]

Agency	Operations		Supporting research		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce	17,125	17,125	305	305	17,430	17, 430
Defense	(94,869)	(95,645)	(825)	(842)	(95,694)	(96,487)
Navy	8,709	9,017	......	......	8,709	9,017
Air Force	86,160	86,628	825	842	86,985	87,470
Transportation	(35,789)	(38,817)	(5,638)	(5,218)	(41,427)	(44,035)
Coast Guard	1,044	899	......	......	1,044	899
FAA	34,745	37,918	5,638	5,218	40,383	43,136
Total	147,783	151,587	6,768	6,365	154,551	157,952

additional 190 domestic airports.

The DOD and FAA have critical unmet needs for continuous updating and improvements of forecasts of ceiling, precipitation, visibility, wind velocity, temperature, slant range visibility, and wind shear for use in aircraft operations. To meet these needs, techniques need to be developed to provide the following parameters:

- Runway visual range measurements at 100-foot increments down to zero visibility
- Slant range visibility
- Low-level wind shear including wake turbulence vortexes
- Automatic measurements of cloud height and amount
- Automatic measurements of prevailing visibility

Table 7 lists the costs of the Aviation Meteorological Service, by agency, for FY 1973 and FY 1974.

Operational Program for Fiscal Year 1974

The Department of Defense is adding specialized meteorological equipment at several of its Naval and Marine Corps Air Stations to improve service to its aviation activities. The FAA has a continuing program to improve service to aviation with the addition of rotating beam ceilometers and runway visual range units at many Category II and III airports.

Research Program for Fiscal Year 1974

DOC is continuing work aimed at the identification of observing techniques that will enable complete automation of synoptic and aviation observations and to design, develop, test, and evaluate hardware for automation. In FY 1974, calibration of a backscatter visibility sensor to determine prevailing visibility will be complete. The field testing of an aircraft ice accretion rate sensor for measuring freezing rain will be complete. In addition, field tests of a passive cloud sensor and a prevailing weather sensor will continue.

The research effort by the Department of Defense continues to be oriented toward specific military requirements. Emphasis will continue on the operation and data gathering from the mesoscale observing network near Bedford, Mass., in an attempt to derive quantitatively better forecasting procedures for short-period terminal forecasting. Work continues to develop techniques for dissipating warm and cold fogs at small, advanced airfields, especially those used by helicopters in resupply and rescue operations. Instruments and techniques which are designed to support land- and sea-based aviation operations continue to receive attention.

The aviation weather research program of the Department of Transportation is designed to provide the technical and operational developments that will improve performance and use of existing components of weather acquisition, transfer, processing, and display equipment. The objective is to modify these specific components for integration into the modernized configuration of the National Airspace System. In this program, the FAA will continue to develop improved techniques for hazardous weather and turbulence detection. By using Doppler radar and other detection devices, the FAA will evaluate techniques and equipment for detecting and predicting clear air turbulence (CAT). It will continue to seek automated methods for improving the accuracy, timeliness, and reliability of aviation terminal forecasts.

In addition, the FAA will investigate methods of improving pilot briefings at FSSs and the feasibility of using automatic data processing in briefing pilots; will investigate the use of an acoustic Doppler sounder for low-level wind measurements; will conduct research on alleviating the effects of aircraft wake turbulence; will investigate meteorological environment in built-up areas as it applies to the operation of vertical and short takeoff and landing (V/STOL) aircraft; and will develop a national fog-dispersal plan for aviation.

The Department of Defense, through its Air Force Cambridge Research Laboratories, will continue a multiyear research program in the application of mesoscale data to terminal forecasting called the Mesonet Project. This research includes a mesoscale network of surface observing stations and a acquisition and processing system.

MARINE METEOROLOGICAL SERVICE

Description

The Departments of Commerce, Transportation, and Defense share statutory responsibility for the Marine Meteorological Service, designed to promote the efficiency of civil and military marine operations and to insure the safety of life and property at sea and on coastal and inland waters. Many segments of the economy—including shipping, commercial fishing, offshore drilling and mining, and recreational boating—as well as the Departments of Defense, Transportation, Commerce, and Interior urgently require detailed forecasts of tides, winds, sea state, surf conditions, and storms.

The objective of the Marine Meteorological Service is to provide expanded coverage and longer range, improved marine weather forecasts to the growing number of marine activities in transportation, recreation, fishing, energy and other offshore resource developments, and national defense. The marine forecast units and local weather service offices need to be expanded, the ability to provide long-term tailored forecasts over the oceans needs to be developed, and there is a need for services designed to support the energy resources development, especially over the formidable marine leg of the Trans-Alaska Pipeline System (TAPS).

The Oceanic Monitoring, Assessment, and Prediction program is being examined to meet the needs for warning, forecast, and assessment services and basic environmental data for the ocean and marine atmosphere. For example, an initial program is being considered in the Gulf of Alaska region and adjacent areas which will be crossed by tankers bringing petroleum from the Alaskan oil fields to the west coast of the United States as part of the overall Trans-Alaska Pipeline System (TAPS). Among the services to be provided in support of TAPS operations are:

- Detailed forecasts of conditions in harbors, ship anchorages, and restricted waterways to increase the safety to ship operations and improve efficiency;
- Improved marine weather forecasts in ocean areas traversed by tankers;
- Improved forecasts of surface and near-surface oceanic conditions such as sea, swell, temperature, and current regimes;
- Assessment of certain water quality parameters through status reports and trends;
- Special forecast services for oil spill and other contingency operations.

Such services should materially contribute to the safety of ship operations and thereby reduce the risk of ship collisions or groundings. But in the event of accidents and resulting oil spills, assessment and prediction will also assist those involved in containment and cleanup operations.

The Department of Commerce is responsible for collecting observations, issuing forecasts and warnings, and disseminating marine meteorological information to benefit the marine industry and navigation. The Coast Guard is responsible for assisting Commerce with observations, warnings, and weather information for the high seas and waters over which the United States has jurisdiction. The Department of Defense is responsible for providing marine meteorological information to its forces.

While at sea, all major commissioned vessels of the U.S. Navy make weather reports that supplement observations largely supplied by the Basic Meteorological Service. Approximately 32 naval vessels have sophisticated equipment for more detailed surface observations, with about 26 of these equipped to make upper air observations. A limited number of buoy-mounted automatic weather stations, now in the prototype stage, are deployed and report regularly. Naval observations are made available to other Federal agencies through routine data collection and exchange. In addition, all large Coast Guard cutters make weather reports at sea, and more than 33 Coast Guard vessels are equipped with balloon inflation shelters for making upper air observations.

NOAA supplements the analysis and forecasting functions of the Basic Meteorological Service with specialized marine support operations at a number of its Weather Service Forecast Offices (WSFO). A Marine Forecast Unit at WSFO Anchorage, Alaska, provides marine support in Alaskan waters, including the Bering, Chukchi, and Beaufort Seas. Particular attention is given to sea ice and its effect on shipping and drilling. The Marine Forecast Unit at WSFO San Francisco has inaugurated an expanded marine environmental service program in cooperation with the U.S. Coast Guard. Weather and sea forecasts and warnings are provided 8 hours a day by radiofacsimile, voice, and Morse telegraphy from the Coast Guard radio station at Point Reyes, Calif. Marine Forecast Units at WFSO Honolulu and WFSO Washington provide high seas marine services in the central North Pacific and the eastern North Atlantic where the

United States has responsibility for shipping forecasts and warnings under the Safety of Life and Sea Conventions and the World Meteorological Organization. In the extreme western North Pacific, Defense provides those services. Marine forecasts and warnings are issued by 17 WFSOs for coastal and offshore waters and by three WSFOs for the Great Lakes. Twenty-one WSFOs serve recreational boaters for lakes and waterways within their area of responsibility as part of the public forecast program. The Great Lakes weather and ice service program is being substantially aided by resources of the Great Lakes and St. Lawrence Seaway Navigation Season Extension Demonstration Program, which is managed by Defense's Corps of Engineers.

A total of four Fleet Weather Centrals supplement the broad-scale products from the Navy's Fleet Numerical Weather Central (FNWC) and NOAA's National Meteorological Center (NMC) by preparing detailed analyses, forecasts, and warnings for their assigned areas of responsibility. In addition, the FNWC and one of the Fleet Weather Centrals provide optimum-track ship routing services to naval vessels and commercial ships operating under Department of Defense contract.

Naval units supplement the Basic Meteorological Service data collection, distribution, and dissemination systems by transmitting weather information along with other traffic on Defense communications systems. In addition, the Naval Environmental Data Network provides for computer-to-computer distribution of products from the FNWC to other Fleet Weather Centrals and Facilities in the United States and overseas areas.

A special service for high-seas shipping was inaugurated by NOAA in cooperation with the National Bureau of Standards, using the time-signal broadcast facilities of WWV (Colorado) and WWVH (Hawaii). It consists of two brief 45-second broadcasts each hour, giving information on major storms in the North Atlantic and North Pacific. Facsimile service from Coast Guard and Defense radio broadcasts is available to specially equipped ships. All Defense naval broadcasts—radio-teletypewriter, voice, and facsimile—are primarily to support naval forces and are subject to change in schedule and content on minimum notice.

Personal marine briefing services are available at all WSFOs having marine service programs; however, most users rely on the various communications systems or on the Coastal Warning System for their information. The latter system is a cooperative network of about 500 visual (flag and light) signals at prominent locations along the coasts, Great Lakes, and inland waterways to advise marine interests when warnings are in effect. The Coast Guard and NOAA operate about one-half of these displays; the remainder are operated by non-Federal interests.

More than 60 Defense weather offices at shore stations and abroad larger ships provide Marine Meteorological Service in support of naval operations.

The Federal Plan for Marine Environmental Prediction provides greater detail on the total Marine Meteorological Services.

Table 8 lists the costs of the Marine Meteorological Service, by agency, for FY 1973 and FY 1974.

Operational Program for Fiscal Year 1974

The small increase in operational costs is primarily the result of the U.S. Coast Guard developing a passive dissemination system for broadcasting environmental information to recreational boaters.

Research Program for Fiscal Year 1974

The Department of Commerce is continuing to emphasize development of automated techniques for producing marine environmental observations and forecasts for oceanic areas, coastal areas, and the Great Lakes. The hurricane storm surge model will be used operationally by the National Hurricane Center. In FY 1974 development work for hurricanes with irregular tracks and compilation of more detailed bathymetric data for surge calculations will continue. Development of wind forecast techniques for the Great Lakes is complete, and these wind forecasts will be input to an automated wave forecast method for the Great Lakes, to be developed in FY 1974. Work also will be started to develop techniques for forecasting surface winds at coastal locations.

The Department of Defense is continuing the development of analysis and prediction models and of techniques to provide a global, automated prediction system. The system will collect, process, disseminate, and display environmental information for use in problems unique to military operations on a near real-time basis. The overall objective is a total system that will, through automatic data processing techniques, process and analyze raw data from land-based, shipboard, airborne, buoy, and satellite meteorological- and oceanographic-measuring systems. Command estimates of the prospective success of environmentally sensitive military operations may then be made by using accurate environmental predictions and interpretations which are derived from advanced data processing and analysis techniques that use air- and sea-coupled mathematical models.

Table 8.—Marine Meteorological Service costs, by agency

[Thousands of dollars]

Agency	Operations		Supporting research		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce	1,743	1,743	123	123	1,866	1,866
Defense	(7,175)	(7,056)	(688)	(1,040)	(7,863)	(8,096)
Navy	7,175	7,056	688	1,040	7,863	8,096
Transportation	(556)	(816)	.....	.....	(556)	(816)
Coast Guard	556	816	.....	.....	556	816
Total	9,474	9,615	811	1,163	10,285	10,778

SPACE OPERATIONS METEOROLOGICAL SERVICE

Description

The Space Operations Meteorological Service provides the specialized weather information required to plan and conduct the Nation's space and missile programs.

Launch sites, missile test ranges, and sometimes recovery areas are instrumented by the user agency to furnish weather information from the earth's surface to an altitude of about 60 kilometers. This information is needed to determine the conditions that missiles and space vehicles will encounter as they are launched or reenter the atmosphere.

Weather observations from local, national, and international networks are used along with weather radar, satellite, and aircraft reconnaissance data as a basis for forecasts and warnings of weather which might affect launch or landing and recovery.

A number of programs, funded by NASA, are supported by meteorologists from the Department of Commerce National Weather Service (NWS). There are NWS teams at NASA facilities at the Wallops Station, Wallops Island, Va.; the Mississippi Test Facility, Bay Saint Louis, Miss.; the J. F. Kennedy Space Center, Cape Kennedy, Fla.; and the Lyndon B. Johnson Space Center, Houston, Tex. The staff at Houston is aided by meteorologists at the NWS National Meteorological Center, the NOAA National Environmental Satellite Service, and NWS offices in Miami and Honolulu. The effort ranges from support studies to participation in flight missions, with exacting weather requirements for launch and recovery.

The Department of Defense provides the Space Operations Meteorological Service for the Eastern Test Range, the Space and Missile Test Center, and the Pacific Missile Range. Networks of surface, radiosonde, and weather radar stations are located on islands and on ships stationed within the Ranges. Specialized staffs at Range Weather Stations provide weather forecasts and planning studies. Defense personnel provide observations through contracts with private industry or through funding agreements with Commerce. Defense also provides for participation in the Meteorological Rocket Network formed to gather atmospheric data from 30 to 110 kilometers above the earth as required by Defense, NASA, the Defense Nuclear Agency, and NOAA for their respective missile, space exploration, atmospheric research, and nuclear effects research projects. Meteorological support to the White Sands, N.Mex., and Kwajalein Missile Ranges and to other Defense-operated research and testing facilities is provided from Defense-supported research funds.

Particularly in the service to manned space flights, there must be weather surveillance and forecasting for large areas of the world to provide for the planned and the many possible emergency landing areas. Meteorological satellite products are extensively used to provide the Space Operations Meteorological Service, especially for the remote ocean areas of both hemispheres.

Table 9 lists the costs of the Space Operations Meteorological Service by agency, for FY 1973 and FY 1974.

Operational Program for Fiscal Year 1974

There is no significant change in program. Inhouse efforts to improve the service are continuing.

Research Program for Fiscal Year 1974

Defense has a continuing program for the development of improved meteorological instrumentation to meet the specialized needs of both the Eastern Test Range and the Space and Missile Test Center. Specialized instrumentation and data are used to assist in scheduling launch operations, in evaluating missile and payload flight performance, in making reentry calculations, and in insuring range safety.

Table 9.—Space Operations Meteorological Service costs, by agency

[Thousands of dollars]

Agency	Operations FY 73	Operations FY 74	Supporting research FY 73	Supporting research FY 74	Total FY 73	Total FY 74
Defense	(6,633)	(6,653)	(842)	(654)	(7,475)	(7,307)
Army	.....	.....	842	654	842	654
Navy	1,074	1,064	.....	.....	1,074	1,064
Air Force	5,559	5,589	.....	.....	5,559	5,589
NASA	1,725	1,779	1,185	1,175	2,910	2,954
Total	8,358	8,432	2,027	1,829	10,385	10,261

As part of the supporting research program, Defense and NASA are improving rockets and rocketborne instruments and are investigating upper atmospheric phenomena through use of rocket data. The NWS teams supporting the NASA manned space programs operationally also conduct a variety of studies oriented toward mission planning and toward development of forecasting techniques for future flights.

AGRICULTURE METEOROLOGICAL SERVICE

Description

The Agricultural Meteorological Service, which includes the Agricultural, Fire-Weather, and Fruit-Frost Weather Services, provides specialized observations, forecasts, and warnings to the agricultural community and to forestry and range management interests. The Department of Commerce is responsible for planning and conducting this Service, whereas the supporting research portion is funded and carried out within the Department of Agriculture as indicated in table 10. The Departments of Agriculture and Interior assist in planning and cooperate in observations, communications, and distribution of information.

Two programs are operated by Commerce to provide service to (1) agriculture and (2) forestry and range management user groups. The *Federal Plan for a National Agricultural Weather Service* describes one; the other is a program to support presuppression, suppression, fire use, and other forestry and range management activities of Federal, State, and private interests. Four and one-half phases of a nine-phase plan for a nationwide service have been implemented according to the *Federal Plan for a National Fire-Weather Service.*

The objectives of the Agricultural Meteorological Service are improved weather forecasts for agricultural management and decisionmaking for the Nation's principal agricultural areas by 1978 and reduced losses from forest fires by increasing National Weather Service support to fire control agencies.

These specialized services are not yet available in all areas where needed. In addition, needs exist in the data collection network required for the fire weather program; for example, meteorological sensors are lacking in remote rural areas.

Specialized observation networks are maintained in agricultural and forestry areas away from the normal observing sites in or near urban areas. In most cases, observations are on a cooperative basis between NOAA and other Federal and State agencies or private interests. Thousands of private citizens serving without pay provide daily measurements of air and soil temperatures, rainfall, and evaporation in crop areas. Observation programs by Federal and State agencies at Agricultural Experiment Stations, colleges, and universities obtain detailed micrometeorological data for studying agriculture-meteorology relations. Approximately 1,100 fire-weather observing stations report daily on a seasonal basis in forested areas, with some stations funded by private interests. Commerce also uses mobile equipment to provide on-the-spot meteorological support to firefighting operations in Western States.

The NOAA Weather Wire Service disseminates forecasts, warnings, and advisories to users and to the mass media in each of the 12 service areas available to the national Agricultural Weather Service. Communications systems, including two-way radios, of Federal and State fire-control agencies are also used to collect observations and to distribute forecasts and warnings, supplementing seasonal fire-weather teletypewriter circuits of the Department.

Forecasts for agricultural users—ranging from a short-period forecast which affects planting, harvesting, crop dusting, and spraying to a 30-day outlook for general agricultural planning—are prepared at Commerce Weather Service Forecast

Table 10.—Agricultural Meteorological Service costs, by agency

[Thousands of dollars]

Agency	Operations FY 73	Operations FY 74	Supporting research FY 73	Supporting research FY 74	Total FY 73	Total FY 74
Agriculture	.....	.....	827	881	827	881
Commerce	1,155	1,155	...	...	1,155	1,155
Total	1,155	1,155	827	881	1,982	2,036

Offices in each of the 12 agricultural service areas. Interpretive and consulting services are provided by 18 Weather Service Offices (Agriculture) at Federal or State experiment stations. A new service for wool growers and livestock producers in Wyoming, North Dakota, and South Dakota makes recorded forecasts and warnings continuously available by telephone from mid-October to mid-May.

Forecasts for fire-weather users—ranging from 5-day extended outlooks through 36-48-hour general forecasts of weather patterns and meteorological elements, such as winds, temperature, rainfall, humidity, thunderstorms, and fuel moisture for large areas, to short-period forecasts for a specific forest fire or warnings of unusually high fire danger in a forest—are prepared at Weather Service Offices (fire weather) by specialists. The Forest Service, Department of Agriculture, contributes to the Fire-Weather Service by supplying fire-weather observations for some 1,100 locations scattered through the National and State forests. Broad-scale guidance is furnished by the Forecast Division of the NOAA National Meteorological Center. Although the FAA does not specifically budget for the national Fire-Weather Service, it plays a significant role in obtaining pilot reports of fires and controlling aircraft involved in firefighting work. Firefighting aircraft require precise observations and forecasts for their hazardous missions.

Forty-four Primary Fire-Weather Offices provide detailed forecasts to local users within their assigned districts, and seven Supplementary Fire-Weather Offices provide similar support in addition to their normal public weather service functions. Twenty-one truck-mounted mobile units, with two-way radio and radio facsimile, deploy at major forest fires to provide immediate support to firefighting.

Table 10 lists the costs of the Agricultural Meteorological Service, by agency; for FY 1973 and FY 1974.

Operational Program for Fiscal Year 1974

Although there are no changes in program, the Department of Commerce continues its efforts to fulfill its responsibilities as indicated in the *Federal Plan for a National Agricultural Weather Service.*

Research Program for Fiscal Year 1974

The Department of Agriculture is conducting the major portion of the supporting research for the Agricultural Meteorological Service. Studies are being conducted on the effect of climatic factors on various insect species and on better uses for beneficial species. Basic studies are being conducted to determine the relationship between climate and such factors as crop hardiness, quality, productiveness, and drought resistance. The Department is directing a national research program on plant disease epidemiology and forecasting in which extensive use is made of micrometerological data observed at the plant level. Studies are being performed to determine the action of air pollutants on plants and methods of controlling the damage. In economics, investigations are being carried out to assess the influences of weather and climate on management decisions.

GENERAL MILITARY METEOROLOGICAL SERVICE

Description

The Department of Defense requires worldwide meteorological support. The General Military Meteorological Service provides general military users with support not available from the Basic Meteorological Service or from other Specialized Meteorological Services. Support for specific users, such as aviation, marine, and space operations, is included in the subsections on the relevant Specialized Meteorological Services.

Requirements of military users include: meteorological information specific to the particular weapons system being developed or employed; unique forecasts and analyses for command and control

Table 11.—General Military Meteorological Service costs, by agency

[Thousands of dollars]

Agency	Operations		Supporting research		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Defense	(31,403)	(31,204)	(14,399)	(15,245)	(45,802)	(46,449)
Army	6,040	5,367	10,158	10,421	16,198	15,788
Navy	8,687	8,690	1,032	1,560	9,719	10,250
Air Force	16,676	16,767	3,209	3,264	19,885	20,031
Total	31,403	30,824	14,399	15,245	45,802	46,069

systems; specialized information such as ballistic data required by field armies and naval units; specialized forecast, impact prediction, meteorological advisory services, and post-test analysis assistance to research, development, test, and evaluation sites; and general meteorological support for training and deployment of military forces and contingency operations.

Hence, various elements of Defense require special meteorological services. To provide them, the Department maintains analysis and forecasting facilities in the United States and abroad. Defense operates the Air Force Global Weather Central (AFGWC) at Offutt Air Force Base, Nebr., the Fleet Numerical Weather Central (FNWC) at Monterey, Calif., and forecast centers in Europe, the Pacific, and the Far East. Specialized centers—such as the U.S. Air Force Environmental Technical Applications Center (USAF ETAC) at Washington and the U.S. Army Atmospheric Sciences Laboratory at White Sands—also fulfill unique military meteorological requirements. Similarly, Defense observation facilities are operated to obtain data in direct support of military operations. Military communications networks are maintained to collect and exchange observations and to disseminate forecasts. Whenever possible, these observations are made available to other Federal agencies.

Also, the Defense aerial reconnaissance force plays a paramount role in specific Defense operations. It provides en route weather observations for refueling, tactical deployments, and contingency exercises, wind information for mass airdrop exercises, and weather observations in missile recovery areas.

In support of tactical operations, the Department has developed and begun procurement of the air-transportable van complexes for meteorological support.

Table 11 lists the costs of the General Military Meteorological Service for FY 1973 and FY 1974.

Operational Program for Fiscal Year 1974

The general curtailment of activities within the Department of Defense and the continued automation and restructuring of selected functions are resulting in significant reduction in manpower costs. Increases are the result of the Air Force improving its capability to provide weather support for tactical operations, which includes purchasing five Tactical Weather Systems and six self-contained tactical weather radars. The Air Force is also increasing its computer power and installing a GOES Data Utilization Station at its Global Weather Central.

Research Program for Fiscal Year 1974

All military research programs are designed to meet the unique requirements of the Department of Defense. Other Government agencies benefit from this research. The Department's research programs have been categorized and discussed under previous subsections of the Plan as research directed toward improvements in a specific Service (e.g., Aviation Meteorological Service). These programs are also considered as research in support of the General Military Meteorological Service because they are directed toward improvements in meteorological support to the overall Defense mission.

The specific objectives of the Department in meteorological research include the following:

- Improvement of the means for meteorological data management, including the collection, dissemination, evaluation, processing, storage, retrieval, display, and quality control of meteorological data and the processing of static data into meaningful and necessary predictions of meteorological conditions.
- Provisions for near real-time meteorological support to weapons systems and tactical operations by the development of new systems such as the Meteorological Data Sounding System AN/UMQ-7(V) and the Automatic Meteorological System (AMS). The AMS is being

Table 12.—Air Pollution Control Meteorological Service costs, by agency

[Thousands of dollars]

	Operations		Supporting research		Total	
Agency	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
EPA	1,000	600	8,530	8,430	9,530	9,030
NASA	.....	.....	95	120	95	120
Commerce	3,625	3,625	.....	.....	3,625	3,625
Total	4,625	4,225	8,625	8,550	13,250	12,775

designed to receive, organize, integrate, and provide the numerous meteorological data (such as those obtained through standard observation, meteorological satellites, and remote sensing devices) in the specific form required by the user (aviation, artillery, combat commander) on a near real-time basis.

- Identification of the impact of environmental conditions on weapons systems and military operations.
- Determination of the atmospheric effects on transmission, refraction, and scattering of acoustic and electromagnetic energy and on dissemination of aerosols and radioactive fallout.
- Rapid conversion of meteorological information into such terms as may be useful to, or required by, operational commanders or be useful in the operation of weapons systems.
- Improvement of weather observations, analysis, and prediction. Automatic observing and reporting systems for rapid, accurate observations of meteorological parameters are required. Improvements are also necessary in the unique observation equipment to support land- and sea-based aircraft operations. Computerized systems for analyzing data and for providing accurate long-range weather predictions are required for all regions of the earth. Particular emphasis is placed on extending the present capabilities of prediction to the tropics, Arctic regions, and the Southern Hemisphere as well as local weather forecasts.
- Development of techniques and methods by which observations from mesoscale surface networks may be used to increase the accuracy of terminal forecasts.

AIR POLLUTION CONTROL METEOROLOGICAL SERVICE

Description

Over 70 percent of the Nation's population is concentrated in some 200 urban areas with less than 10 percent of the country's land area. Solution of the rapidly developing air pollution problem associated with urbanization demands the coordinated efforts of Federal, State, and local governmental activities. The Air Pollution Control Meteorological Service provides essential meteorological data and forecasting to Federal, State, and local governmental agencies responsible for dealing with urban air pollution and advises the public of weather conditions that may lead to serious air pollution episodes. The Department of Commerce is responsible for this Service, which includes: surface and upper air observations necessary to describe the weather in urban areas, air stagnation forecasts in sufficient detail to provide the basis for air pollution control decisions, and applied research to improve these observations and forecasts. The operational responsibilities are discharged in NOAA by its Air Pollution Weather Service which consists of 43 Air Stagnation Advisory Offices, 18 of which have Environmental Meteorological Support Units (EMSU), and six offices that provide meteorological advisory service for smoke management. The applied research is accomplished principally by NOAA personnel assigned to the Environmental Protection Agency's (EPA) Meteorology Laboratory.

The objectives of the Air Pollution Control Meteorological Service are to (a) establish and maintain weather service support to those urban regions where the threat of critical air pollution episodes still exists, and (b) increase the utility of air pollution weather forecasts by improving their timeliness, lead time, and accuracy. With regard to objective (a), the threat of air pollution episodes in some urban areas has diminished so that special support is no longer required at the previous level of effort. When this occurs, the associated EMSU support is reduced or withdrawn.

In addition to the Air Pollution Control Meteorological Services provided and programmed for

Table 13.—Other Specialized Meteorological Service costs, by agency

[Thousands of dollars]

Agency	Operations FY 73	Operations FY 74	Supporting research FY 73	Supporting research FY 74	Total FY 73	Total FY 74
AEC	1,564	1,852	675	680	2,239	2,532
Defense	(10,003)	(10,034)	...	...	(10,003)	(10,034)
Army	230	240	...	...	230	240
Navy	1,435	1,411	...	...	1,435	1,411
Air Force	8,338	8,383	...	...	8,338	8,383
Total	11,567	11,886	675	680	12,242	12,566

selected urban areas, the Environmental Protection Agency has expressed the view that additional forecasting services may be required in nonurban areas to predict those conditions that are not condusive to the rapid dispersion of smoke generated by agricultural and forest slash burning. EPA is responsible for working with State and local governmental agencies to insure adequate meteorological support programs. These services are specified in the *Federal Plan for Air Pollution Control Meteorological Service,* published by the Federal Coordinator for Meteorological Services and Supporting Research.

In addition, Commerce monitors the long-term global trends of selected trace constituents and properties of the atmosphere having a potential influence on climate change.

Table 12 lists the costs of the Air Pollution Control Meteorological Service, by agency, for FY 1973 and FY 1974.

Operational Program for Fiscal Year 1974

The Department of Commerce plans to reduce certain of its programs. EMSUs are being discontinued at Boston, Detroit, St. Louis, and Cleveland, and low-level soundings are being reduced by one per day at five other locations.

Research Program for Fiscal Year 1974

The research program of the Environmental Protection Agency is in direct support of mission functions and is primarily concerned with solving high-priority problems in connection with establishing and enforcing pollution control regulations and for the provision of pollution control technology.

A major thrust of current and proposed atmospheric research seeks to provide objective tools for use in the development of least-cost pollution control strategies, land use and transportation planning for pollution control, pollution episode forecasting and control, and as aids to pollution monitoring networks. The development of Air Quality Simulation Models will permit EPA to describe and evaluate the impact of air pollution on urban and nonurban environments, and provide quantitative description of the impact of air pollution on weather, visibility, and climate.

Observation and descriptions of the state of the atmosphere receive major emphasis. Approximately half of the observational funds are directed toward defining air pollution on a regional scale and providing the basic input data for development of descriptive simulation models. The remaining observational funds are divided between research related to specific urban health problems (Community Health Environmental Surveillance Studies) and research directed toward defining trends in urban and rural air pollution (National Air Quality Sampling Network).

The urban and rural air pollution trend research program has been in progress for several years at over 200 sites throughout the United States. Part of the increase in observation funds starting in FY 1973 is the result of establishing and maintaining 25 new stations to support the regional investigations and 25 new stations related to urban health research. A major contributing factor to the increase in observational funds and decrease in physical meteorology is the result of realinement and redefinition of programs in response to the needs for research on regional air pollution problems.

OTHER SPECIALIZED METEOROLOGICAL SERVICES

Description

Several Federal agencies and user groups vitally need other specialized meteorological services, but less than discussed in previous sections. In general, these are either supporting weather services for research and development or operational activities not large enough to warrant a separate service category. These meteorological service programs generally support stable, ongoing activities in which year-to-year changes are usually small. The programs included are:

- The Department of Defense programs for meteorological support to civil works projects and to some of its research, development, test, and evaluation activities such as equipment design and testing, geophysical laboratories support, and polar research operations.
- The Atomic Energy Commission (AEC) programs for meteorological support to its laboratories and test sites.

Table 13 lists the operational costs of the Other Specialized Meteorological Services, by agency, for FY 1973 and FY 1974.

Operational Program for Fiscal Year 1974

The Other Specialized Meteorological Services support relatively stable ongoing programs so there are no significant changes.

Research Program for Fiscal Year 1974

The AEC research program includes an important element which provides support for a large and changing operational program. This support consists of the evaluation and prediction of atmospheric transport and diffusion and of atmospheric cleansing mechanisms such as deposition and washout.

Supporting research for reactor tests includes studies of mesometeorological motions and dilution patterns predicted by a mathematical model and verified with tracer experiments. The motion and dilution of effluents in the immediate wake of large structures is evaluated with field and wind tunnel tests.

The evaluation of safety aspects associated with the transport and storage of nuclear supply systems for space missions requires studies of the movement and composition of aerosol and gaseous radioactive materials extending from the earth's surface to orbital reentry altitudes.

Plant safety as well as operations and building costs are seriously affected by uncertainties as to tornadic winds, and a project is supported in a NOAA laboratory to obtain Doppler radar measurements of actual winds in tornadoes.

Measurements and supporting studies are necessary for assessing the environmental impact of numerous postulated Commission experiments including underground testing of nuclear devices and atmospheric testing of nuclear rockets. Meteorological data are collected to permit the assessment of the effect of these variables on the relocation of aerosols previously deposited on the ground. A broad variety of modeling is being developed for application to studies of the long-range effects of various peaceful uses of nuclear explosives.

CLIMATOLOGY

Introduction

Climatology, part of the Basic Meteorological Service, is the continuing use of historical weather data to improve knowledge of weather and its effects upon life and property, economic development, and long-range planning. This section describes the climatological programs, funds for which are reported under Basic Meteorological Services.

Description

Collection, quality control, analysis, interpretation, storage, application, publications, and retrieval of past meteorological data are fundamental parts of climatological programs. Numerous governmental and private agencies use climatology in their mission-oriented research, studies, and planning. National efforts to store and process climatological data have been consolidated in a joint civil-military complex, the National Climatic Center (NCC), at Asheville, N.C. At NCC the Department of Commerce discharges its basic responsibility for archiving all meteorological data, for providing quality control of civil data, and for processing data to meet civil requirements. The Department of Defense also contributes meteorological data and performs part of its quality control and climatological processing at this location. Defense and Commerce share the use of a computer system at Asheville; Defense also contracts some of its processing and quality control to Commerce.

Operation of NCC is basic to the Commerce program conducted by its Environmental Data Service. Special requirements for climatological observations are met through a modest network of climatological reference stations and the support to a large network of cooperative substations. Services include: Publication and distribution of data and summaries to large user groups; information services responsive to requests for special information; processing data to fulfill unique user specifications; and supporting research to improve understanding of climate and its data application to user needs and to improve services. The Weather Service Offices provide contact points for local climatological service.

The U.S. Air Force Environmental Technical Applications Center (USAF ETAC) provides climatological services and products to the Air Force and Army and makes its data available to authorized users in the Department of Defense and other agencies of the Federal Government. The Air Force Global Weather Central (AFGWC) receives data in near real-time by means of the

Automated Weather Network. Data are shipped to ETAC on magnetic tape for climatological purposes. The Data Processing Division of ETAC at Asheville further processes Air Force meteorological records for storage and retrieves and processes for special military requirements. Commerce and Defense share records and facilities maintained at Asheville. Field climatological units and staff meteorologists provide specific services to military users, exploiting centralized facilities for fast, flexible response to individual environmental problems.

Some Defense climatological needs are served by Commerce at NCC on a contract basis. The Defense program at NCC includes such functions as quality control, conversion of data to machine-processable form, and processing of these data to produce marine climatic atlases and special studies. NCC performs these functions on a reimbursable basis and, as the responsible Federal agency, archives the data for general use. Defense also funds the acquisition of otherwise unavailable foreign marine data on a global basis. Unclassified climatological publications and data are made available routinely to other Federal agencies and to the public through established channels. Special analyses applied to individual problems are an increasing portion of this program.

Military command and control systems increasingly emphasize the need for immediate access to selected climatological parameters on a global basis. Defense has committed substantial resources to this long-term task and is compiling special summaries for about 5,000 airfields worldwide. The project involves exhaustive data searching, keypunching, and computer editing, processing, and printing of reports. There is also a continuing project to convert these data to tabular form. The data are available to the public through the National Technical Information Service (NTIS) of Commerce at Springfield, Va.

The NCC joint-use computer system at Asheville enables both the Departments of Commerce and Defense to exploit the capability of large-capacity mass-memory files and provides immediate access to frequently used data by either date or location. Selected data are also maintained in the processing systems at AFGWC and the Fleet Numerical Weather Central to support their operational systems.

Many other Federal agencies use weather records and climatology in internal studies, research, or planning without identifying a specific climatological program or function. Examples are the evaluation and analyses of water resources by the Department of Interior and the research and planning in weather-crop relations by the Department of Agriculture. The Department of Health, Education, and Welfare and EPA have supported development of a national climatology of air pollution potential. Support will be continued for observation, storage, and processing of meteorological parameters affecting the incidence, transport, and dissipation of air pollution. The relevance of climatic factors to such problems as waste accumulation, housing, accidents, and disease (human, animal, and crop) is also recognized. The research by AEC on the probable fate of radioactive contaminants released into the atmosphere uses climatology. NASA observes and studies fine-scale features for application to aerospace vehicle design and operation. The National Science Foundation sponsors some research in climatology and recognizes that climatological service is a supporting requirement for much ongoing meteorological research.

Technological advances require updating climatology's traditional supporting role. Traditional user activities are subject to increasingly precise analysis and design for greater reliability, economy, and effectiveness; new areas like exploitation of space, development of marine resources, and understanding of man's interaction with his environment require attention. This shift has been manifest in the creation of environmental data centers to supplement the original NCC; for example, the National Oceanographic Data Center, National Geophysical and Solar Terrestrial Data Center, Environmental Science Information Center, Center for Environmental Data Design and Analysis, and National Space Science Data Center. Climatological requirements frequently enter these associated areas and such purely meteorological areas as fine-scale composition, structure, motion, and variations in the atmosphere and their associated physical, optical, and electromagnetic effects. It is increasingly necessary for the climatological services to be integrated with related disciplines for support.

Operational Program for Fiscal Year 1974

Except for the program of providing climatologists for the States, which has been eliminated, climatological services for FY 1974 are being continued at previous levels, and efforts to improve services within the resources available are continuing.

Research Program for Fiscal Year 1974

Climatological research by Commerce will continue in FY 1974 in the general areas of data collection and analysis. Specifically in data collection, work will continue in the design of Reference Climatological Stations and in recommending, monitoring, reviewing, and testing large-scale data acquisition systems and data reduction processes.

Data analysis techniques will be directed toward (1) defining those critical relations and thresholds through which environmental conditions influence major economic and social activities, (2) estimating the probable occurrence of these conditions as a basis for planning and design, (3) devising ways to avoid or to alleviate them through understanding and interpreting climatological records, and (4) assisting data processors in meeting the needs of data users in terms of quality, redundancy, variability, and length of records.

Studies are planned to investigate (1) the merging of satellite-based weather observations and conventional surface observations into improved climatological products, (2) the mapping of ground temperature and moisture as they influence vegetation and other biological activities, (3) the statistical nature of climatic change, particularly as it may be inadvertently affected by man's activities, (4) the impact of meteorological knowledge on the design and operation of future systems of electric power production and distribution, (5) the utility of climatological data in concurrently improving food production and environmental quality, and (6) the application of climatological statistics to the building of structures.

Operational Functions

INTRODUCTION

Five distinct functions are common to all Basic and Specialized Meteorological Services. These are observations, analyses and forecasts, communications, dissemination to users, and general agency support. The total Federal operations for each of these functions are described in this section of the Plan. Following each description are the program changes for FY 1974 as projected by the agencies to meet the Federal goals. Table 14 lists the agency operational costs, by function, and table 15 lists the agency manpower engaged in weather operations, by function, for FY 1973 and 1974. Agency research programs are described in the Services section of this Plan and are not repeated here. However, table 16 lists the agency supporting research costs, by function, for FY 1973 and FY 1974.

OBSERVATIONS

Description

The objectives of the basic observing function are observations of sufficient density, frequency, and quality to serve the common needs of Commerce, other Federal and foreign government agencies, commercial users, and the general public. Five general categories of observations constitute the basic function supporting the Federal meteorological services—surface, upper air (balloon and rocket), aircraft reconnaissance, weather radar, and weather satellite systems. These are described in greater detail in later paragraphs of this subsection. Table 17 shows the number of locations, by function, for each of the agencies for FY 1973 and FY 1974.

The Departments of Commerce, Transportation, and Defense have common requirements for surface observational data along the coast and over the oceans to serve marine commerce and shipping, national defense, port and harbor management, recreational boating, offshore industry, sport and commercial fishing, and to support the National Response Team in the event of oil and other hazardous material spills.

Currently there are needs for capability to obtain reliable worldwide profiles of temperature, humidity, density, and winds up to 100,000 feet in both cloudy and cloud-free atmospheres. Also, better weather radar coverage over mountainous areas of the western United States is needed, and much of the radar network needs to be modernized.

Table 14.—Agency operational costs, by function

[Thousands of dollars]

	Observations		Analyses and forecasts		Communications		Dissemination to users		General agency support		Total	
Agency	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
AEC	766	908	......	......	16	19	109	130	673	795	1,564	1,852
Commerce	65,609	80,542	44,306	49,118	6,181	6,556	18,103	19,573	34,054	34,914	168,253	190,703
Defense	60,991	64,308	21,085	22,895	20,909	19,497	34,796	32,244	46,578	45,919	184,359	184,863
EPA	400	150	150	150	......	......	50	100	400	200	1,000	600
NASA	306	281	587	668	96	76	135	170	601	584	1,725	1,779
Transportation	(14,728)	(13,453)	......	......	(17,579)	(17,537)	(12,834)	(14,813)	(9,766)	(10,456)	(54,907)	(56,259)
Coast Guard	9,900	8,440	......	......	155	163	345	600	209	209	10,609	9,412
FAA	4,828	5,013	......	......	17,424	17,374	12,489	14,213	9,557	10,247	44,298	46,84
Total	142,800	159,642	66,128	72,831	44,781	43,685	66,027	67,030	92,072	92,868	411,808	436,056

Table 15.—Agency manpower engaged in weather operations, by function

[Thousands of dollars]

	Observations		Analyses and forecasts		Communications		Dissemination to users		General agency support		Total	
Agency	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce......	1,704	1,749	1,707	1,849	113	113	1,146	1,118	1,421	1,456	6,091	6,355
	[1] 80	[1] 80	[1] 50	[1] 50	.....	.....	.....	.....	[1] 16	[1] 16	[1] 146	[1] 146
Defense	2,879	2,132	1,143	979	1,214	1,022	2,929	2,558	2,152	1,940	10,317	8,631
	[2] 339	[2] 336	[2] 396	[2] 392	[2] 230	[2] 228	[2] 189	[2] 187	[2] 1,892	[2] 1,888	[2] 3,046	[2] 3,031
	[1] 5	[1] 5	[1] 6	[1] 6	[1] 2	[1] 2	[1] 2	[1] 2	[1] 17	[1] 17	[1] 32	[1] 32
NASA..........	......	4	1	6	......	......	......	3	4	13	5	26
	[1] 4	[1] 4	......	......	......	......	......	......	......	......	[1] 4	[1] 4
Transportation:												
Coast Guard..	151	151	......	......	......	......	......	......	......	......	151	151
	[2] 1,740	[2] 1,570	......	......	[2] 10	[2] 10	[2] 9	[2] 9	[2] 20	[2] 20	[2] 1,779	[2] 1,609
FAA.........	[2] 288	[2] 295	......	......	[2] 773	[2] 693	[2] 761	[2] 839	[2] 428	[2] 448	[2] 2,250	[2] 2,275
Total..........	7,190	6,326	3,303	3,282	2,342	2,068	5,036	4,786	5,950	5,798	23,821	22,260

[1] Funded by other agencies.

[2] Man-years.

Table 16.—Agency supporting research costs, by function

[Thousands of dollars]

	Observations		Description		Prediction		Dissemination		Systems		Support		Total	
Agency	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Agriculture........	234	254	337	358	256	269	......	......	......	......	......	......	827	881
AEC..............	338	340	239	272	68	68	......	......	......	......	......	......	675	680
Commerce.........	2,567	2,622	550	550	910	910	200	200	250	275	340	360	4,817	4,917
Defense...........	5,742	6,088	3,851	4,205	2,865	3,293	154	46	3,942	599	4,100	3,950	20,654	18,181
EPA.............	5,880	5,780	2,600	2,600	50	50	......	......	......	......	......	......	8,530	8,430
NASA.............	28,768	29,396	......	......	......	......	......	......	910	900	......	......	29,678	30,296
FAA.............	1,158	829	......	......	263	13	1,396	1,548	2,821	2,828	......	......	5,638	5,218
Total.............	44,687	45,309	7,607	7,985	4,412	4,603	1,750	1,794	7,923	4,602	4,440	4,310	70,819	68,603

For analysis of environmental impact, a need for additional special benchmark stations at high altitudes has been identified. A need has also been expressed for an economical, mobile, low-level sounding system for use in smoke management by forest, agriculture, and air pollution control agencies.

The Department of Commerce and Department of Transportation have common requirements for observational data at airports, although the uses or services to which the data are applied are different. The Departments also have common requirements for weather observations to support en route air navigation.

Finally, weather modification activities of the several Federal agencies require a capability for accurate ice nuclei counts at weather reporting stations of Commerce's National Weather Service.

SURFACE OBSERVATIONS

Federal agencies take surface weather observations at approximately 1,100 locations to support basic analysis and forecasting and certain specialized services. This effort does not include the approximately 13,000 cooperative observation stations manned by volunteers and the cooperative observation networks that support agriculture and fire-weather observations in the 50 States, Puerto Rico, and territories and possessions. In addition, Federal agencies either take or support observations on many ships at sea and at a limited number of sites within other countries. The U.S. effort is supplemented with surface observations by other nations so that a global network of observations is available for analysis and forecast by processing centers in this country and in all other countries concerned.

Table 17.—Number of locations by observation function, fiscal years 1973-74

Observation function	Agency	FY 73	FY 74
SURFACE (land)	Commerce [1]	511	536
	Defense	269	256
	Transportation (FAA)	347	359
	NASA	3	3
	AEC	2	2
SURFACE (marine)	Commerce (moving vessels with meteorological personnel)	0	0
	Commerce (merchant ships cooperative program)	2,305	2,305
	Transportation (Coast Guard)[2]	247	244
	Defense (ships with meteorological personnel)	32	28
	Commerce and Transportation (ocean stations)	6	5
UPPER AIR (rocket)	NASA (U.S.)	1	1
	NASA (overseas)	1	1
	Defense (U.S.)	8	8
	Defense (overseas)	13	13
	AEC (U.S.)[3]	1	1
	AEC (overseas)[3]	2	2
UPPER AIR (balloon)	Commerce (U.S.)	106	106
	Commerce (overseas)	40	40
	Commerce (ship)	0	0
	Defense (U.S.)	5	5
	Defense (overseas)	11	11
	Defense (ship)	26	25
	Defense (mobile)	13	15
	NASA (U.S.)	3	3
	AEC (U.S.)	2	2
	Commerce and Transportation (ocean stations)[4]	6	4
WEATHER RADAR	Commerce (U.S.)	51	51
	Defense (U.S.)	96	99
	Defense (overseas)	36	26
	Transportation (Coast Guard)[5]	1	1
	NASA (U.S.)	2	2
WEATHER RECONNAISSANCE	Defense (No. of aircraft years)	29	29

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[1] Cooperative stations operated by Departments of Agriculture, Interior, and Transportation, other public and private agencies, and those manned by volunteers are not included. Also excluded are 272 Supplementary Aviation Weather Reporting Stations and foreign cooperative stations included in previous plans.

[2] Includes 96/93 ships and 151 shore stations supporting marine activities.

[3] No operational funds programmed.

[4] Department of Transportation (Coast Guard) has 36 vessels, including six icebreakers, equipped for upper air observations. These support the ocean station vessel programs and other activities as required.

[5] Ocean Weather Station Hotel.

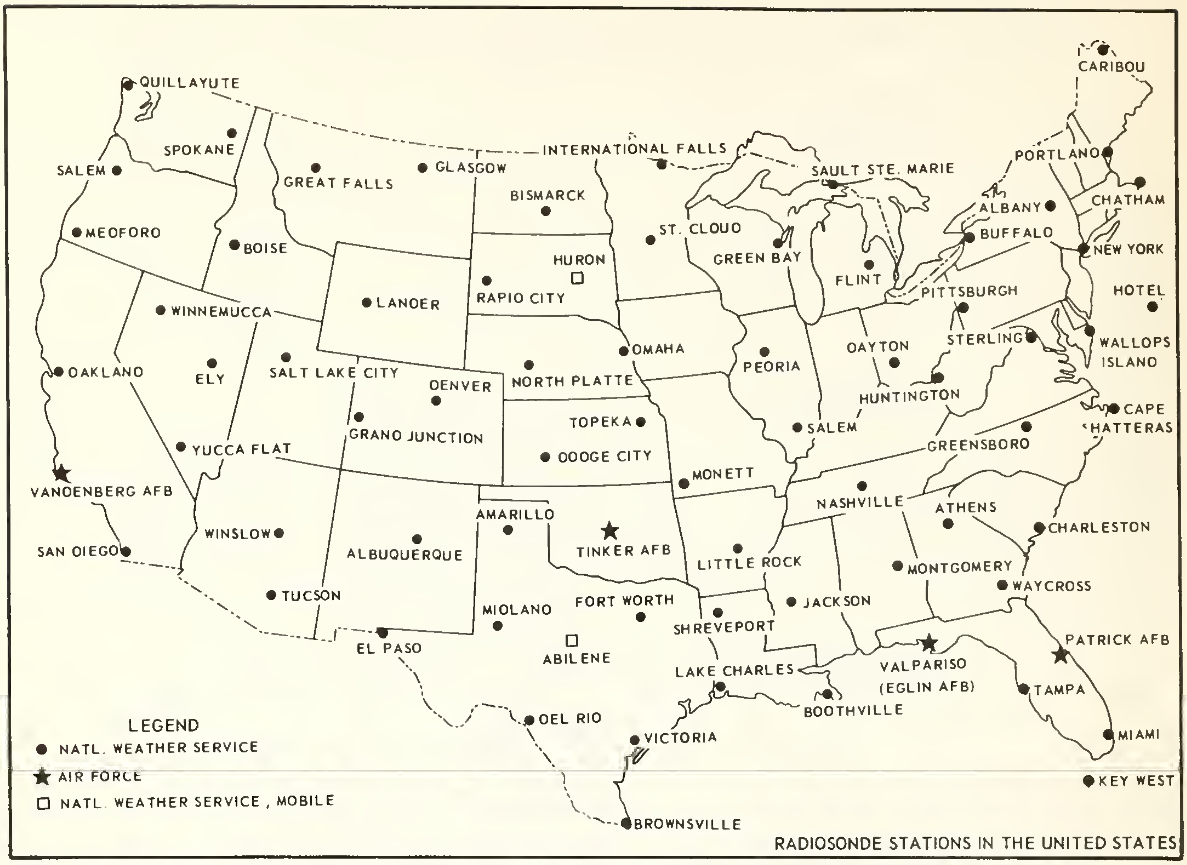

FIGURE 2.—Network of upper air observation stations in the United States.

UPPER AIR OBSERVATIONS

The Basic Upper Air Observation Network provides upper air observations that form the basis for numerical analysis, general forecasts, and warnings. The Network is composed of Department of Commerce stations—supplemented by stations operated on a cooperative basis by Commerce with Canada, Mexico, and Caribbean and Latin American countries—and other Federal facilities in the United States and overseas. Figure 2 shows this network within the conterminous States. In addition, a number of Government ships (Commerce, Defense, and Transportation) make upper air observations which supplement the fixed land stations in the Network by giving minimal data over the oceans. Vertical sounding data from polar-orbiting satellites are providing an increasing amount of useful data to supplement other data over the oceans.

Upper air observations are also taken, generally on an unscheduled basis, at test ranges and at some research facilities for specialized support, and by Defense facilities in support of severe local storms forecasting, military operations and training, and other programs. The developing air pollution control activities of EPA and of State and local control authorities require detailed information on the vertical structure of the atmosphere over urban areas. Low-level upper air observations taken twice daily to about 10,000 feet provide these data and supplement the regular upper air network. These low-level upper air observations are entered on the Service C Teletypewriter System where they can be used effectively by analysis and forecast centers for such functions as severe local storm warnings. The upper air program in this country is supplemented with upper air observations by other nations so that a global network of observations (from approximately 850 stations) is available for analysis and forecast.

Both NASA and the Department of Defense make extensive use of upper atmospheric data obtained from rocketsondes for supporting their spacecraft launching activities. The centers at Huntsville, Ala., Langley, Va., Houston, Cape Kennedy, Vandenberg and Edwards Air Force Bases (AFB), Calif., and Wright-Patterson AFB,

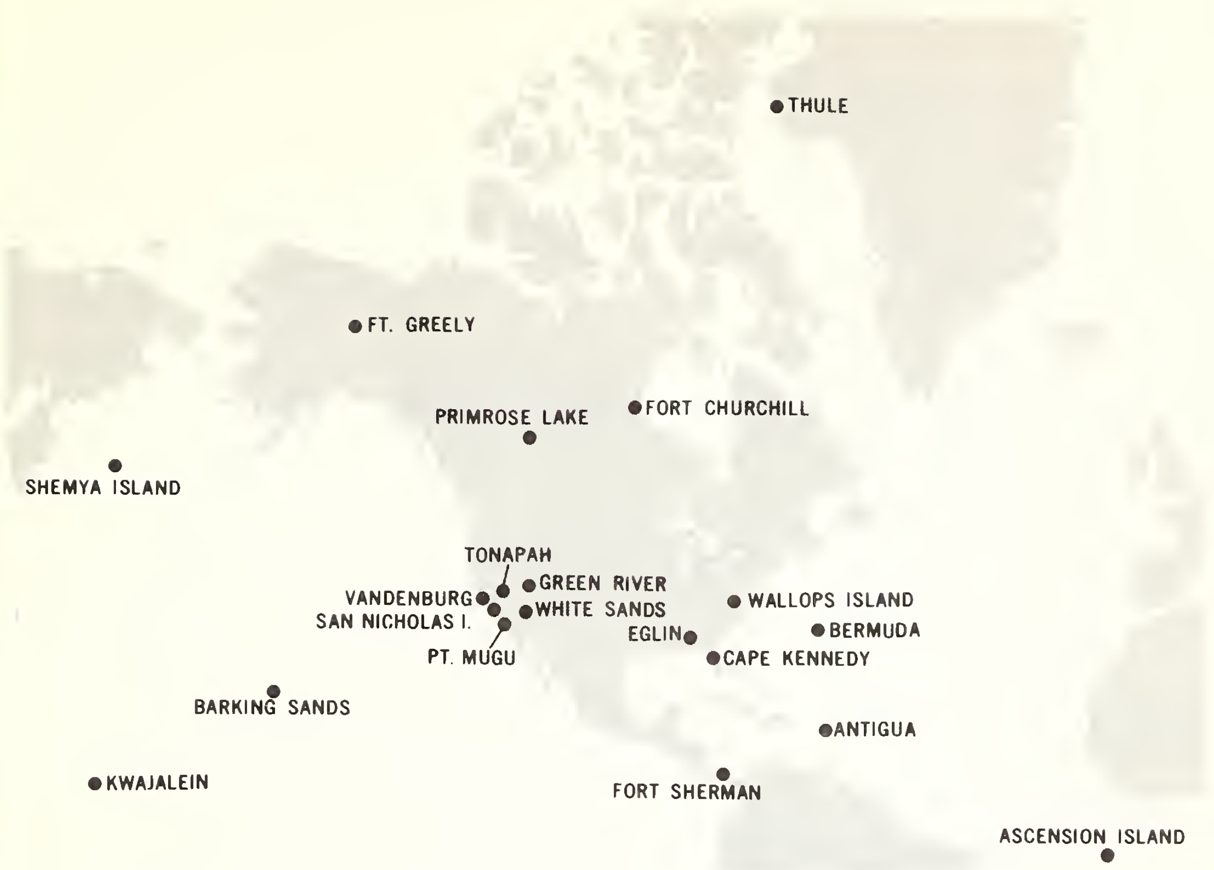

FIGURE 3.—Network of rocketsonde stations operated by agencies of the Federal Government.

Ohio, are the prime NASA and Defense users of these data. The rocketsonde network is shown in figure 3.

Commerce monitors long-term global trends in atmospheric constituents and properties likely to produce climatic change. These observations (surface and upper air) are now made at the Mauna Loa Observatory on a routine basis.

WEATHER RECONNAISSANCE OBSERVATIONS

The Department of Defense aircraft reconnaissance program provides weather information and meteorological measurements at flight altitude along specific tracks. Instruments dropped from aircraft provide sounding data from flight altitude to the earth's surface at specified reporting points. This method of observation is principally used over large ocean areas where other weather information is sparse or nonexistent. In some cases, oceanographic information is also obtained on these flights.

Reconnaissance flights are made to investigate suspected storm areas and to obtain precise data on the location, movement, and physical characteristics of tropical cyclones in the western Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and Pacific Ocean, and of winter storms off the east and west coasts of the United States. Procedures for these reconnaissance flights are included in the National Hurricane Operations Plan and the National East Coast Winter Storms Operations Plan. High altitude reconnaissance flights are conducted to collect data in support of various meteorological research programs. Support is provided to NOAA, NCAR, AFCRL, and more recently to DOT in conjunction with the Climate Impact Assessment Program.

Still other types of reconnaissance are conducted in support of specific Defense operations. Special weather reconnaissance observations are provided in support of tactical land, sea, and air operations. These include troop maneuvers, mass airdrops, missile launches and recoveries, fleet exercises, and air refueling operations.

The Department of Defense has six WC-135s, 22 WC-130s, and four WP3A aircraft equipped for weather reconnaissance. The WP3As are equipped with bathythermograph equipment for measuring ocean temperatures to a depth of 1,000 feet.

Defense weather reconnaissance has been supplemented by data, obtained by Department of Commerce research aircraft, on hurricanes in the North Atlantic Ocean, Caribbean Sea, and Gulf of Mexico and on winter storms off the east coast of the United States. These aircraft are funded under research programs.

All Commerce research aircraft have now been grounded for the last half of FY 1973 from budgetary reasons. In FY 1974 Commerce will reactivate two aircraft, the WC-130 and a DC-6.

WEATHER RADAR OBSERVATIONS

Radar, one of the principal sources of weather information, is used in preparing vital weather warnings to the public, industry, and Government and in providing observations that protect life and property as well as give control and safety to aircraft in flight. These observations provide:

- The best method now available for remote identification and tracking of squall lines, tornadoes, and other destructive storms.
- A means for locating, tracking, and estimating the intensity of hurricanes as they approach the U.S. coastal areas.
- The information upon which estimates of precipitation rates and amounts can be based for use in flash-flood warnings and in managing water resources within river basins.
- The detection of probable convective storm turbulence.

There are two general categories of uses or needs for these radar data. The first requires systematic observations from a network of radars to give data for tracking and predicting intensities and motion of relatively large areas of precipitation. The second requires detailed information on which a civil or military weather service office can base short-period forecasts and warnings of significant weather. Such uses include advisories to airborne pilots, air traffic controllers, and pilot weather briefers.

The *Federal Plan for Weather Radars and Remote Displays* identifies the need for local and network weather radar observations and describes a coordinated long-term program to meet these needs most effectively and economically. The Synoptic Weather Radar Network, established in this Plan to make detailed observations on a scheduled basis, uses Department of Commerce and certain Department of Defense weather radars. Air Traffic Control radars of FAA are also used in some Western States to supply limited observations in a region where weather radar installations are extremely expensive and severe weather is relatively infrequent.

Observations from the radar network in the conterminous States are collected at a central location, compiled, and transmitted over facsimile systems and teletypewriter networks to civil and military weather service offices for use in forecasts, warnings, and pilot briefings beyond the range of their local radar coverage.

Figure 4 shows the location of network radars as of FY 1972.

WEATHER SATELLITE OBSERVATIONS

The satellite is playing an increasingly important role, along with more conventional techniques, in producing meteorological data for weather analysis and forecast, storm warnings, and oceanographic forecasts. The ITOS D, now NOAA 2, was launched October 15, 1972. This satellite provides cloud imagery, both day and night, from its scanning and very high resolution radiometers and vertical temperature profiles from its vertical temperature profile radiometers. These meteorological data satisfy, to a certain extent, the common requirements for upper air data over the ocean areas. The developing national operational environmental satellite system is described under Weather Satellites, page 48.

Program Changes for Fiscal Year 1974

Table 18 lists the total operational costs, by agency, for each type of observation for FY 1973 and FY 1974.

The accelerated curtailment of activities within the Department of Defense brought about additional program decreases in FY 1973 over those previously projected. The U.S. Army deactivated nine field artillery meteorological sections for a reduction of $1,562,000. The U.S. Air Force FY 1973 program to purchase and install 30 lightning detectors at $360,000 was not funded. The Air Force also reduced their airborne weather reconnaissance hours and expendables with a saving of $4,587,000, and their programs to modify weather reconnaissance aircraft for the Advanced Weather Reconnaissance System (AWRS), Seek Storm, and weather modification were placed in abeyance pending further study and use of the prototype system for a reduction of $4,520,000. The Air Force experienced increases in FY 1973 over that previously reported because of delays in planning for consolidating and restructuring of observing work centers and of higher pay levels, totaling $1,637,000; costs associated with installing and relocating runway visual range (RVR), digital wind, and other equipment amounting to an additional

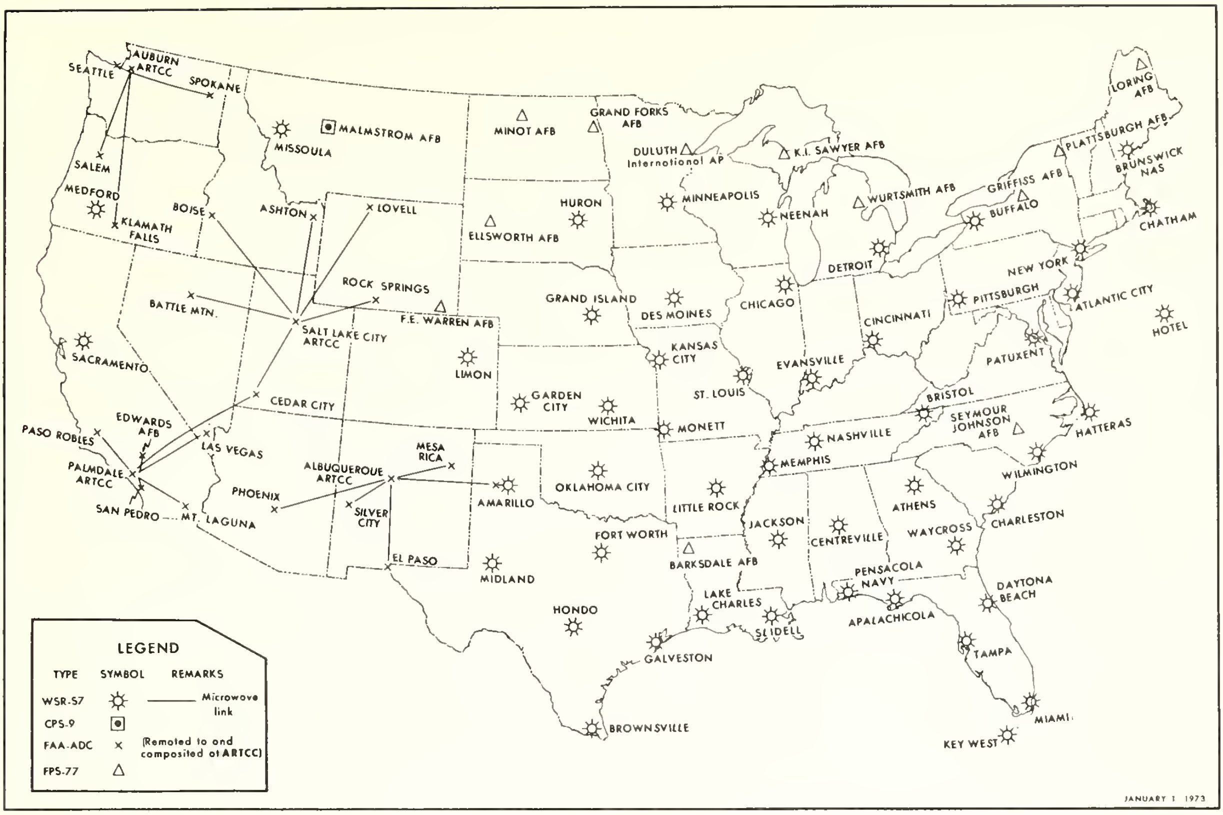

FIGURE 4.—Synoptic Weather Radar Network.

$1,235,000; and costs of relocating weather sensor readouts and communications equipment from representative observation sites to base weather stations at approximately 100 sites amounting to $3,000,000. Other programs not previously reported by the Air Force in FY 1973 include a new rocketsonde station at Shemya, Alaska, at $130,000, beginning modification of HC-130H aircraft to WC-130H configuration and purchase of AMT-13 dropsondes at $1,282,000, and replacing CPS-9 weather radars at Scott AFB, Ill., and Wright-Patterson AFB, Ohio, with existing FPS-77s at $140,000.

Also the Navy began a program in FY 1973 to expand utilization of satellite information at its Fleet Weather Centrals with the purchase of six analog/digital converters, recorders, and other associated equipment at $500,000. It also reduced its HASP III rocketsonde system program from 500 to 300 systems but with additional support, test equipments, and meteorological probes for a total of $500,000—hence an increase of $200,000 over that previously indicated.

For FY 1974 the Air Force is planning reductions in its observer manpower, from consolidating and restructuring observer work centers, in the amount of $1,792,000. The cost to relocate weather sensor readouts and communications equipment from representative observation sites to base weather stations reflects a $1,000,000 reduction; the cost to install and relocate RVR, digital wind, and other observing equipment reflects a reduction of $800,000 because of completion of some projects; and a prorated adjustment of cost of aerial weather reconnaissance brings an additional reduction in the amount of $133,000. Planned increases by the Air Force include the procurement of six self-contained tactical weather radars for the Tactical Weather System and selected local applications at $1,228,000; increased costs for expendables at the new facility at Shemya at $137,000; continued modification of HC-130H aircraft to reconnaissance configuration and the purchase of more dropsondes with an increase of $6,272,000; and the installation of a satellite field service station at AFGWC to utilize GOES data at $396,000. The

Table 18.—Agency operational costs, by type of observation

[Thousands of dollars]

	Surface		Upper air (balloon)		Upper air (rocket)		Weather reconnaissance		Weather radar		Weather satellite		Total	
Agency	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
AEC	280	333	486	575	......	......	......	......	......	......	......	......	766	908
Commerce	24,663	24,638	15,138	15,122	......	......	......	......	5,154	7,066	20,654	33,716	65,609	80,542
Defense	14,193	10,881	6,613	5,772	2,432	2,467	35,682	41,527	875	2,139	1,196	1,522	60,991	64,308
EPA	......	......	400	150	......	......	......	......	......	......	......	......	400	150
NASA	88	75	155	121	28	50	35	35	......	......	......	......	306	281
Transportation	(6,808)	(6,701)	(7,920)	(6,752)	......	......	......	......	......	......	......	......	(14,728)	(13,453)
Coast Guard	1,980	1,688	7,920	6,752	......	......	......	......	......	......	......	......	9,900	8,440
FAA	4,828	5,013	......	......	......	......	......	......	......	......	......	......	4,828	5,013
Total	46,032	42,628	30,712	28,492	2,460	2,517	35,717	41,562	6,029	9,205	21,850	35,238	142,800	159,642

Air Force program to replace CPS-9 weather radars with FPS-77s at Pope and Kincheloe AFBs is continuing at the same rate of $140,000.

The U.S. Navy's ongoing program to convert Runway Visual Range (RVR) systems at its Naval and Marine Corps Air Stations to provide visibility information for landing aircraft was completed in FY 1973 which accounts for a reduction of $100,000 in FY 1974. The Navy is continuing to equip and modify its weather reconnaissance aircraft in FY 1974 at $500,000, an increase of $179,500 over FY 1973. This increase is a prorated share increase applicable to meteorology and not an overall Navy program increase. The Navy's ongoing program to expand the use of meteorological satellite observations at its Fleet Weather Centrals is being continued in FY 1974 at $400,000, a decrease of $100,000 from FY 1973. In other ongoing programs the Navy is continuing, at approximately level funding, the purchase of 350 HASP III rocketsonde systems at $500,000; the purchase of nine APT photorecorders and converting 22 shipboard meteorological satellite receiving equipments to receive GOES WEFAX transmissions at $700,000; purchase of three weather radars as replacements for obsolete equipment at $450,000; and purchase of six semiautomatic weather stations for use at Naval and Marine Corps Air Stations at $150,000. In a new program for FY 1974, the Navy plans to procure miscellaneous meteorological equipment, including sferics, weathervision monitors, and ceilometer amplifiers to improve local observing capability at Naval and Marine Corps Air Stations at $550,000.

The FAA program in FY 1973 to procure 11 rotating beam ceilometers has been deferred and accounts for a reduction of $235,000.

The U.S. Coast Guard has decommissioned three vessels as a result of disestablishing Ocean Station Echo. The prorated share of the reduction attributable to meteorology amounts to $1,800,000 in FY 1974. (The USCG will decommission 10 more vessels during FY 1974 for an additional prorated reduction of $3,960,000. This information was received too late to be included in the budget tables.)

The Department of Commerce programs for FY 1973 have been adjusted to delete obtaining radio receiving equipment for two ships and for acquiring low-level upper air sounding units. In FY 1974, Commerce is placing emphasis on fulfilling the common requirements of the Federal agencies by improving its surface and radar observing programs and its utilization of meteorological data from satellites.

Commerce plans to begin site preparation and equipment rehabilitation looking toward the FY 1975 installation of WSR-57 network radars in southern Virginia and eastern Texas (total two radars) needed to fill major gaps in the network at $420,000 and to purchase 18 WSR-74 local-use radars to replace obsolete equipment and supplement network radars in providing data for short-period forecasts and warnings at $1,500,000. To meet budget limitations, the upper air observations in the Trust Territory are being reduced to one a day for an annual saving of $75,000, and the weather station at Shemya, Alaska, is being eliminated for an annual saving of $84,000.

The satellite observing programs are included in a separate section, Weather Satellites, of this Plan. In addition to these programs, Commerce plans to improve the utilization of data from satellites by equipping an additional 20 WSFOs with data display devices capable of producing photo-quality displays of data from polar-orbiting satellites at $220,000 and by equipping and staffing additional WSFOs to receive, display, and use the high-quality image data from the geostationary satellites at $750,000.

ANALYSES AND FORECASTS

Description

There are three major types of analysis and forecast centers: primary, area and guidance, and specialized. Primary centers produce basic analyses and forecasts and provide basic warning services. Area and guidance centers supplement the products of primary centers and adapt them to their particular regions. Specialized centers serve the unique requirements of specific user groups or provide a service not available from other centers such as fire-weather support.

PRIMARY CENTERS

The Department of Commerce operates four primary centers. The NOAA National Meteorological Center (NMC) at Suitland provides basic weather analyses and forecasts for the Northern Hemisphere and for portions of the Southern Hemisphere. During a typical day NMC processes more than 40,000 surface observations, 2,000 ship reports, 1,500 upper air soundings plus several hundred vertical soundings derived from satellite data, 2,800 aircraft reports, and global cloud-cover data from weather satellites. Products of NMC include more than 500 facsimile and 200 teletypewriter transmissions daily to its users primarily in North America but also in overseas areas.

The Department's responsibility for establishing and operating a national operational environmental satellite system is fulfilled by the NOAA National Environmental Satellite Service (NESS) at Suitland. The NESS, in addition to managing all operational meteorological satellite operations, processes data from both operational and research and development meteorological satellites to provide outputs required by civil and military users. The resulting products have made significant contributions to forecasts and warnings of hurricanes and other major severe storms by providing information on their existence and intensity in those areas where conventional observations are sparse or nonexistent. The NMC and NESS, along with the National Climatic Center at Asheville, collectively form a World Meteorological Center with global responsibilities for analyses and forecasts and for collection and retrieval of data under the international program World Weather Watch.

The NOAA National Hurricane Center (NHC) and the Regional Center for Tropical Meteorology (RCTM) are operated by Commerce and collocated in Miami. The NHC provides basic forecasts and warnings of hurricanes in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico for all Federal agencies and user groups. The RCTM, designated by the World Meteorological Organization as a part of the World Weather Watch, produces basic analysis and forecast information for the tropical latitudes, supplementing the mid- and high-latitude products of NMC. Major objectives of the NHC are to: improve timeliness and accuracy of the hurricane warning program by developing automated data handling and displays to accommodate the increasing volume of data from satellites and aircraft reconnaissance; reduce the average position error in the 24-hour hurricane forecast; and advance the warning time for hurricanes approaching coastal areas.

A better understanding of the dynamics of hurricanes and of the basic environmental parameters necessary for hurricane prediction is needed, as are prediction models and techniques and adequate data on hurricane location, movement, and intensity.

The NOAA National Severe Storms Forecast Center (NSSFC) at Kansas City, Mo., is the source for severe thunderstorm and tornado watches in the United States in support of civil needs. The Center is responsible for the preparation and release of watches that designate areas where the likelihood of severe thunderstorms or tornadoes is high.

Major objectives of the NSSFC are to improve the tornado and severe thunderstorm warnings by reducing the number of people unnecessarily warned in a potential severe local storm situation and developing computer data handling and displays. Although techniques used in forecasting and warning of tornadoes and severe thunderstorms have vastly improved in the past 20 years, needs for knowledge continue to be critical. Far too many people are unnecessarily alerted by the overly large tornado watch areas, 43 percent of which verify with one or more tornadoes. Furthermore, only about 30 percent of the reported tornadoes are in valid watch areas. Improved forecast and warning techniques can only follow continued investigation and more knowledge of this small, violent storm.

The Department of Defense operates four primary centers. The Air Force Global Weather Central (AFGWC) at Offutt AFB provides basic analysis and forecast products in support of worldwide Defense aerospace and ground operations. Products from AFGWC are distributed to globally dispersed Defense facilities and forces by facsimile, teletypewriter, and high-speed communications systems. The European Weather Central, Croughton Air Station, England, and the Asian Weather Central, Fuchu Air Station, Japan, have been considered primary centers serving their large areas of responsibility. However, they are phasing down, their functions being absorbed in large part by AFGWC, and will henceforth be considered area and guidance centers. The Navy Fleet Numerical Weather Central (FNWC) at Monterey provides analysis and forecast products for the Northern Hemisphere in support of naval requirements. Products from FNWC are disseminated over the Naval Environmental Data Network (NEDN) to Fleet Weather Centrals and Facilities located strategically throughout the world and to Naval Weather Service Environmental Detachments (NWSED), and to naval ships through interlinking fleet facsimile and teletypewriter broadcasts. The recent advent of high-speed data link communications has made it technologically possible and economically advantageous for direct computer-to-computer exchanges of products among Defense processing centers.

The threat of power shortages and failures along the eastern seaboard jeopardizes the capability of NMC to provide basic weather analyses and forecasts. A cooperative arrangement has been developed to provide continuous service in such a contingency. Should NMC fail because of a power or computer failure, AFGWC will provide selected essential meteorological charts for entry on the National Facsimile Network (NAFAX) at Kansas City.

AREA AND GUIDANCE CENTERS

Area and guidance centers form the intermediate level in the weather analysis and forecasting structure. These centers, using the products of primary centers, are responsible for forecasts and warnings within their assigned areas. They also provide detailed guidance and support to civil or military weather service offices within their areas.

The Department of Commerce operates 46 area and guidance centers, Weather Service Forecast Offices (WSFO), in the United States and one in Puerto Rico. Each WSFO provides forecasts and warnings for one or more States or for large portions of one State for periods up to 48 hours. Short-period warnings on hazardous weather situations are issued to the general public by all NOAA Weather Service Offices (WSO). The Hurricane Warning Offices at Boston, Mass., Washington, D.C., New Orleans, La., and San Juan, P.R., after coordination with NHC, are responsible for warnings in their respective areas of responsibility. In accord with international agreements, the Eastern Pacific Hurricane Center at San Francisco, Calif., and the Central Pacific Hurricane Center at Honolulu, Hawaii, provide forecast and warning services over the eastern and central Pacific Ocean similar to those provided by NHC for the Atlantic, Caribbean Sea, and Gulf of Mexico. Hurricane advisories and bulletins prepared by the Warning Offices for the general public and the marine interests contain the position, intensity, direction and rate of movement, and other significant characteristics of the storm. The Department of Defense Joint Typhoon Warning Center on Guam prepares typhoon warnings for the North Pacific west of longitude 180°.

A special, intensive watch by the Regional Warning Coordination Center (RWCC) in New York City, N.Y., in cooperation with several Federal agencies, is being kept on a 150-mile-wide strip of the Atlantic along the east coast to detect and track storms approaching the densely populated coastal region from these offshore waters. Ships, planes, satellites, and an instrumented buoy provide the NWS with the observations needed to issue timely warnings.

A major objective of Commerce's centers is more detailed and timely forecasts and warnings for smaller areas. Expanding requirements for more accurate and timely weather warnings and forecasts in support of both safety and planning for day-to-day activities, travel, and recreation highlight an urgent need for forecasts and warnings to concentrate on more accurate timing of critical events occurring on smaller space scales. Forecasting of heavy snow remains one of the most difficult tasks facing the operational meteorologist, since it involves three primary questions which need to be resolved in time and space. First, will precipitation be in the form of rain or snow? Second and third, how heavy and how long will the precipitation be? Answers to these questions are vital because an inch of rain is equivalent to about 10 inches of snow. Further research is needed to develop better techniques for forecasting heavy snow.

The Department of Defense operates four area and guidance centers in the United States and six in overseas areas to meet its global military requirements. These centers are uniquely oriented to support military operations. Meeting the military needs for weather warning service is the Severe Weather Warning Forecast Center (SWWFC), a branch of the Air Force Global Weather Central (AFGWC). Located at Offutt AFB, Nebr., the SWWFC provides tailored severe weather warnings to 600 Defense and Defense-contracted agencies. Severe weather warnings are transmitted in a narrative and graphical form. They depict areas

Table 19.—Agency operational costs, by type of center

[Thousands of dollars]

	Primary		Area and guidance		Specialized		Total	
Agency	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce.........	18,626	23,038	8,956	9,356	16,724	16,724	44,306	49,118
Defense...........	11,422	13,903	6,135	4,978	3,528	4,014	21,085	22,895
EPA...............	....	....	....	....	150	150	150	150
NASA.............	587	668	....	....	....	....	587	668
Total..............	30,635	37,609	15,091	14,334	20,402	20,888	66,128	72,831

within the conterminous United States having the potential to produce weather phenomena which can have a hazardous effect on aircraft and ground operations. In addition, point warnings are provided for a large number of military locations. These warnings, which are transmitted directly to the affected installations by means of defense communications system teletypewriter circuits, define the type, intensity, and duration of the expected hazardous weather.

SPECIALIZED CENTERS

Specialized centers meet the unique requirements of a specific user group. Center personnel are trained in special areas such as agricultural, marine, and aviation meteorology so that they can better understand and meet the user's needs.

The Department of Commerce has specialized centers to serve aviation, agriculture, air pollution control, and fire-weather activities. Personnel for these specialized centers are usually collocated within large-area centers, producing information for their particular user groups. With funding support from NASA, Commerce provides small but highly specialized centers to support the space program. The NOAA National Climatic Center (NCC) at Asheville is the central archival, processing, and service center for weather records collected by all Federal agencies.

The Department of Defense agencies operate two specialized centers in the United States: USAF Environmental Tactical Applications Center (ETAC) and its subunit at Asheville, N.C., and the Joint Typhoon Warning Center overseas to support unique military needs.

Program Changes for Fiscal Year 1974

Table 19 lists the total operational costs, by agency, for the three types of centers for FY 1973 and FY 1974.

Because of the general curtailment of activities within the Department of Defense and increased automation and restructuring of functions, the U.S. Air Force reduced its manpower authorizations at primary and specialized centers during FY 1973 with a total saving of $2,242,000. Concurrently, the Air Force programmed an increase of $268,000 for installation of a 1110 computer and associated centralized functions at its Global Weather Central and $849,000 in the last three quarters of FY 1973 for lease of the computer, with an additional $351,000 in FY 1974 for a full year's lease. Also in FY 1974, the Air Force plans to increase the capability at ETAC to use the ARPA net at $486,000, and personnel costs in the centers are expected to increase by $702,000 despite a reduction in the number of personnel. The U.S. Navy in FY 1973 is introducing a capability to process satellite data at the Fleet Numerical Weather Central for $592,000. For FY 1974 it is expanding this capability and purchasing automatic data processing equipment for it for an additional amount of $1,847,000.

Department of Commerce increases in FY 1973 spending (previously reported) to improve analysis and prediction have been deleted, except for $800,000 for computer testing new analysis and forecast methods and $273,000 for developing methods for assimilating new data from satellites into the numerical prediction models. The program to maintain and operate Environmental Meteorological Support Units (EMSU) in urban areas of critical potential for pollution episodes has been reduced by a modest $50,000 in FY 1973 and an additional $450,000 in FY 1974.

The Department of Commerce is continuing and expanding its program toward meeting the long-term goals of improved meteorological services and satisfied common requirements. In this connection the Department, in FY 1974, plans to expand its program of purchasing time on an upgraded computer to run a more accurate and detailed forecast model at $1,250,000 and, through reprogramming action, is developing a numerical hurricane model to provide improved guidance with respect to the 24-hour movement of mature hurricanes.

COMMUNICATIONS

Description

The communications function exists to support the environmental prediction and warning service by collecting and distributing environmental data for use in forecasts and warnings to Federal, State, and local agencies and to the general public. The capability to collect, display, and distribute environmental information rapidly in sufficient time to issue short-period forecasts and warnings is a principal need.

Rapid communications facilities for meteorological operations are essential to the timely collection of weather data for centralized processing and for direct application by many user groups. Weather communications facilities are also used to distribute processed information from processing centers and civil and military weather service offices to the public and to various specialized users. Demands for improved service created by the increasing range and speed of modern aircraft require the timely collection and exchange of observations from most areas of the world for operational uses and for inputs to the analysis and forecasting routines at weather centers.

For more than 40 years, teletypewriter systems have been a means for collecting and distributing observations and forecasts. Facsimile systems are now widely used to distribute weather maps and other products from weather centers. Demands for increased amounts of data, greater collection speed, and more products from computers in weather centers have led Federal agencies to increase their use of high-speed digital systems as replacements for some teletypewriter and facsimile networks. High-speed data transfer is generally accomplished by computer-to-computer links.

To enhance the effectiveness of weather communications and to promote coordinated weather communications systems planning, the Manager, National Communications System (NCS), and the Federal Coordinator for Meteorology sponsored the formation in June 1972 of the NCS Weather Communications Coordinating Committee (NCS WCCC). As stated in its Terms of References, the objective of the NCS WCCC is maximum coordination of future meteorological communications systems planning, resulting in more efficient equipment utilization and system compatibility among the Federal agencies concerned.

The NCS WCCC, whose membership includes representatives of all Federal agencies which operate weather communications systems, has met regularly since June 1972. The committee has completed an exchange of information on communications systems and selected R&D projects of multiagency interest, such as high-speed facsimile systems and distributive processing systems. During calendar year 1973 it is anticipated that interagency planning in specific areas will be coordinated.

The major communications systems in use and which receive the attention of the NCS WCCC are described in the following paragraphs.

TELETYPEWRITER AND HIGH-SPEED SYSTEMS

Federal Aviation Administration

The Modernized Weather Teletypewriter Communications System (MWTCS) consolidates the circuit control and relay functions of Services A, C, and O into a single Weather Message Switching Center (WMSC) at Kansas City. These functions are performed automatically by a group of electronic computers combined to operate as a realtime store and forward communications switch. All Service A and C circuits extend directly into the WMSC. Certain Service O circuits also extend directly into the computer switch, while others, from overseas points, pass through the Aeronautical Fixed Telecommunications Network switch which is collocated and interconnected with the WMSC. Computer-to-computer links provide for the exchange of data between the WMSC and the National Meteorological Center (NMC) at Suitland and between the WMSC and the U.S. Air Force Automated Weather Network (AWN) at Carswell AFB, Tex.

Circuits of the MWTCS are classified and described as follows:

- *Service A Area Circuits:* Forty 100-wpm (words per minute) multipoint half-duplex circuits designed solely to meet the collection and routine distribution requirements of the average FAA and National Weather Service (NWS) user. Other users may obtain receive-only drops on these circuits if their needs are incidentally compatible with those of FAA and NWS.
- *Service A Request/Reply Circuits:* Forty 100-wpm half-duplex circuits which parallel the Service A Area Circuits and enable Government flight briefing facilities to obtain information not routinely transmitted to the associated Area Circuit.
- *Service A Low-Speed Nongovernmental Circuits:* Fourteen 100-wpm multipoint circuits for the distribution of data to meet the requirements of nongovernment users, princi-

pally airlines whose needs are not satisfied by the Area Circuits.

- *Service C Area Circuits:* Six 100-wpm multipoint half-duplex circuits for the collection and distribution of Service C data to serve both Government and nongovernment users.
- *Service O Area Circuits:* 67- and 100-wpm multipoint half-duplex circuits for the collection and distribution of Service O data to both Government and nongovernment users.
- *Air Force Circuits:* Twenty-one 100-wpm multipoint circuits for the distribution of Service A, C, and O data to high-volume AFBs in the United States whose needs cannot be met by Area Circuits alone.
- *Weather Service Forecast Office Point-to-Point Circuits:* Forty-three 100-wpm full-duplex circuits to the Weather Service Forecast Offices (WSFO) for transmission of forecast products to the WMSC and receipt by the WSFOs of supplementary weather data.
- *Radio Broadcast Circuits:* 60-wpm distribution-only circuits for the transmission of data on the World Meteorological Organization and Caribbean Meteorological (CARMET) broadcast.
- *Government Medium-Speed Circuits:* 1,200-bps (bits per second) multipoint receive-only circuits for the distribution of Service A, C, and O data to very-high-volume FAA and NWS users whose needs cannot be satisfied by Area Circuits.
- *Nongovernment Medium-Speed Circuits:* 1,200-bps multipoint receive-only circuits for the distribution of Service A, C, and O data to very-high-volume airlines and other nongovernment users whose needs cannot be satisfied by Low-Speed Circuits.
- *High- and Medium-Speed Links:*

  2,400-bps full-duplex computer-to-computer circuit for the exchange of Service A, C, and O data between the WMSC and NMC.

  1,200-bps full-computer-to-computer circuit for the exhange of Service A, C, and O data between the WMSC and the U.S. Air Force Air Weather Service.

  1,200-bps full-duplex Notice to Airmen (NOTAM) circuit between the WMSC and National Flight Data Center.

Department of Commerce

Radar Report and Warning Coordination (RAWARC) Teletypewriter Network. The landline teletypewriter network used to collect and to distribute radar reports and storm warning information is RAWARC. The Network is composed of five circuits. They terminate at the Radar Analysis and Development Unit (RADU) in Kansas City, which is the monitor station for the Network, and Communications Operating Branch, Suitland, Md., which is the Automated Relay Center. Traffic on RAWARC is basically unscheduled and is handled according to a priority system. The only regularly scheduled operation on RAWARC is an hourly collection of Radar Reports (SD) which are relayed by Suitland as required.

Special Communications Links Between Guidance Centers. A high-speed numeric and graphic computer link was established in FY 1971 between the National Meteorological Center/National Environmental Satellite Service (NMC/NESS) of NOAA and the NHC to improve the exchange of aircraft reconnaissance data, satellite data, and processed information. A similar link has been established between the NMC/NESS and the NSSFC.

International circuits. The Department of Commerce operates five international circuits to exchange meteorological data among the United States and Canada, the U.S.S.R., Great Britain, Japan, and Brazil. These include a Washington-Toronto high-speed circuit; a Washington-Moscow circuit for exchange of satellite information; a Washington-Buenos Aires low-speed circuit; and three other circuits—Washington-Bracknell (England), Washington-Tokyo, and Washington-Brasilia—that are part of the World Weather Watch main trunk circuit. The Washington-Bracknell circuit is also used to exchange facsimile charts.

Radio circuits. Weather messages and observations prepared aboard ships at sea are transmitted by radio, primarily by means of international Morse code, to shore-based radio stations. These messages are relayed to NMC. The Teletypewriter Exchange Service (TWX), international communications carrier facilities, and U.S. Coast Guard circuits are used for the relays. Observations are automatically separated geographically and consolidated into bulletins which are distributed on domestic and international meteorological communications facilities. More than 1,000 observations are processed daily.

Department of Defense

Automated Weather Network (AWN). The AWN, operated and maintained by the U.S. Air Force, is the backbone of the military weather communications system. It consists of four real-time communications switching computers at Carswell AFB, Tex., RAF Croughton, England, Fuchu Air Station, Japan, and Clark Air Base, Philippine Islands, linked by high-speed data circuits. The overseas Automatic Digital Weather Switches (ADWS) collect data from radio intercept sites and low-speed feeder circuits. These data are transmitted at 3,000 wpm to the Continental United States (CONUS) ADWS at Carswell AFB where the information is examined, sorted, edited, compiled into specific weather messages, and switched to military and civil customers. Besides low-speed distribution to Department of Defense weather units, data are transmitted by high-speed circuits to the Air Force Global Weather Central (AFGWC), Fleet Numerical Weather Central (FNWC), NMC, and the WMSC at Kansas City. All circuits are full-duplex, permitting a total exchange of data—both raw reports from field units to the military and civil processing centers and products from these centers to the field units.

CONUS Meteorological (COMET) Teletypewriter System. The primary communications system for collecting, editing, and disseminating environmental data at military stations in the United States is COMET, consisting of three teletypewriter networks—COMET I, COMET II, and COMET III. Each of these teletypewriter networks is subdivided into eight geographical areas. The COMET I Network consists of half-duplex 100-wpm loop circuits used for collecting and disseminating airways data. The COMET II Network consists of full-duplex 100-wpm loop circuits used for the collection and dissemination of operational weather products and data. The COMET III Network consists of half-duplex 375-wpm broadcast circuits used for disseminating synoptic data. Polling for data collection on COMET I and COMET II and dissemination of data over COMET II and COMET III are controlled by the 1108 computer at the Carswell ADWS.

Naval Environmental Data Network (NEDN). NEDN provides for the dissemination of meteorological and oceanographic computer products from FNWC at Monterey to specially equipped locations in the United States and overseas. The Network rapidly collects, processes, disseminates, and displays environmental data; it consists of online telecommunications equipment, automated display devices, digital computers, and associated circuitry.

FACSIMILE

Department of Commerce

National Facsimile (NAFAX) Network. The NAFAX is a long-line network generally used to distribute a comprehensive set of charts depicting analysis, forecast, and selected observational data to civil and military weather service offices and to a variety of other users. Basically a graphics network, the NAFAX serves approximately 250 WSOs, 320 military and other civil governmental offices, and nearly 350 nongovernmental users—more than 900 drops in all.

With the exception of the radar summary charts from RADU and the digitized mosaics from the National Environmental Satellite Service (NESS), all materials originate at NMC. The Network extends throughout the United States, with connections into Canada at Vancouver and Montreal. Charts are relayed to Alaska over military channels from West Sweetgrass, Mont. In Alaska, selected charts are put on the Intra-Alaska Facsimile Network circuit. Selected charts are also relayed to Honolulu.

Aviation Meteorological Facsimile (AMFAX) Network. The AMFAX is a long-line network designed to distribute graphic analyses and forecasts to offices supporting international high-altitude aviation operations.

Graphic guidance materials in the form of manually prepared forecasts are entered on the circuit at Montreal, Honolulu, and by the NMC at Suitland. Additional entries are numerically prepared forecast charts from NMC and digitized cloud mosaics from NESS. At selected times during the day, the Network is linked to the Intra-Alaska Facsimile Network, the Canadian Facsimile Network, and to international broadcast lines serving Honolulu, San Juan, and other countries.

National Aviation Meteorological Facsimile (NAMFAX) Network. The NAMFAX is a new long-line network designed to provide selected centers with a combination of graphical material carried on NAFAX and AMFAX. The network operates at variable speed (120 or 240 scans per minute) and has automatic selection of speed and mode. When completely implemented, it will replace the AMFAX Network.

Forecast Office Facsimile (FOFAX) System. The FOFAX is a long-line network designed to distribute forecast guidance materials prepared by NMC and satellite products from NESS to the WSFOs. The System is also used to distribute NESS digitally prepared mosaics obtained from satellite pictures and automatic picture transmission data acquired by NESS Wallops Island, WSFO San Francisco, and U.S. Air Force Air Weather Service at Kunia, Hawaii. The System operates at variable speed (120 or 240 scans per minute) and has automatic selection of speed and mode.

Tropical Regional Analysis Facsimile Circuit (TROPRAN). The TROPRAN is a long-line network used to distribute tropical area analyses and prognoses. The Circuit carries NMC products for use by the National Hurricane Center and provides the NESS tropical-area satellite data for all users on the Circuit.

Intra-Alaska Facsimile Network. This Network is a system of microwave, troposcatter, cable, and high-frequency radio facilities used to distribute graphic materials throughout Alaska. Besides the charts prepared by the WSFO Anchorage, selected charts are switched automatically into the Network from NAFAX and AMFAX. At present the Intra-Alaska Facsimile Network serves 10 NWS, one Coast Guard, and eight Defense offices. The FAA and NOAA provide funds for that portion of the AMFAX circuit from the international border-crossing point at Blaine, Wash., to Smugglers Cove, Alaska. The NWS of NOAA provides approximately 90 percent of the funds for circuitry within Alaska, and the Department of Defense supplies the remainder.

Department of Defense

Strategic Facsimile Network. The Strategic Facsimile Network is a landline and microwave net that extends to selected Defense users at approximately 80 locations in the United States. The AFGWC at Offutt AFB serves as the transmitting facility. The Strategic Facsimile Network supplements the facsimile systems of the Department of Commerce by providing specialized graphic data oriented to military operations. It is used primarily to support the readiness of U.S. strategic weapons forces and secondarily to support airlift and tactical forces. The Network operates at 120 scans per minute and utilizes RJ-4-type facsimile recorders. Most products are computer generated and introduced into the system through digital-to-analog converters.

Fleet Weather Broadcasts. The Naval Communications System supports the Naval Weather Service in its requirements for specialized operational communications. Meteorological traffic is handled in the same manner as other traffic; no centers or units are dedicated exclusively to meteorological communications. However, equipment needed to key transmitters and to receive data is installed directly in weather offices. Meteorological information is transmitted to operating forces of the Navy by means of radio (continuous wave, teletypewriter, and facsimile) broadcasts. These broadcasts are prepared by the Fleet Weather Centrals and Facilities and include observations, analyses, forecasts, and warnings. In preparing broadcasts, the Centrals and Facilities make use not only of their own specialized products and those from the FNWC but also—to the extent possible—of products from the Basic Meteorological Service and of data received from AWN.

Program Changes for Fiscal Year 1974

The following paragraphs highlight program changes for the total communications function, and table 20 shows the total cost, by agency, of the various types of communications for FY 1973 and FY 1974.

For FY 1974 some significant changes are being programmed. The continued curtailment of activities within the Department of Defense is causing reductions in weather communications support and the consequent reduction in personnel with a saving of $1,326,000.

The Department of Commerce is expanding its role in providing basic services and improving its hazards warning capability. The RAWARC system is being extended to 32 WSOs now without this service and the speed increased to 100 wpm at $225,000. The National Facsimile Service is being extended to 23 additional Weather Service Offices at $150,000. In addition, Commerce's program to automate its field operations and services is expected to undergo field trials. To support these trials, a central computer and a prototype field station are to be provided at $400,000.

The FAA has continued to modernize the weather communications facilities at its WMSC in Kansas City, has added 100 command FSS locations, and has provided communications to automatic meteorological observing stations (AMOS). Pay raises and delays in the planned elimination of editing and relay services account for most of the increases reflected in FY 1973 over that previously reported. In FY 1974, the savings resulting from the reduction in manpower in editing, relay, and maintenance are being largely offset by pay raises and increases in leased services such that there is little change in the total program.

Table 20.—Agency operational costs, by type of communications

[Thousands of dollars]

Agency	Teletypewriter and high-speed systems		Facsimile		CW, voice, telescriber and television		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
AEC	8	9	8	10	...	...	16	19
Commerce	4,055	4,269	2,126	2,287	...	...	6,181	6,556
Defense	14,479	12,446	5,671	6,307	759	744	20,909	19,497
NASA	33	24	18	22	45	30	96	76
Transportation	(16,791)	(16,685)	(788)	(852)	...	...	(17,579)	(17,537
Coast Guard	77	81	78	82	...	...	155	163
FAA	16,714	16,604	710	770	...	...	17,424	17,374
Total	35,366	33,433	8,611	9,478	804	774	44,781	43,685

DISSEMINATION TO USERS

Description

After weather observations have been collected and processed, the forecast and warning products must be presented in the proper form to the general public or user group for which the service is designed. This final step in the production of meteorological services occurs in civil and military weather service offices. The products are conveyed to their consumers by personal briefings in the weather service offices; by voice communications devices such as telephones, telephone-answering recorders, and recorded broadcasts; by direct radio broadcasts on commercial AM/FM stations; by telescribers; by closed-circuit television; by the NOAA Weather Wire Service (NWWS); and by the Coastal Warning System. The Weather Service Offices (WSO) of the Department of Commerce provide up-to-date information to newspapers and to radio and television stations, using those outlets as the principal means to reach the general public.

The objectives of the dissemination function are a capability to provide timely forecasts and warnings through dissemination or alerting systems that reach 95 percent of the populace; accelerated efforts to work with local agencies and the Defense Civil Preparedness Agency (DCPA) in developing adequate community preparedness programs; and availability of real-time weather information for use in aircraft operations.

In addition to the dissemination of routine forecasts, specific needs are to provide individual news media, community preparedness organizations, and the general public with timely warnings of severe weather. The time requirement varies from a very few minutes in the case of a tornado warning to several days for widespread snowmelt-type flood warnings. At present, much of the warning and forecast system is manual, and a comprehensive analysis on programs to automate field operations and services is underway.

WEATHER SERVICE OFFICES

The Department of Commerce through NOAA has approximately 235 Weather Service Forecast Offices (WSFO) and WSOs that provide forecasts and warnings to the general public and to responsible State and local officials.

Hurricane and tornado warnings are distributed immediately by all available means of communication, but with heavy reliance upon radio and television broadcasting. NOAA weather offices throughout the country make basic dissemination of hurricane and tornado warnings, with key dissemination nerve centers at NHC and NSSFC.

Commerce's NOAA operates a continuous radio weather broadcast service consisting of 65 VHF/FM facilities. This broadcast, at 162.40 and 162.55 MHz, provides continuous weather forecasts and warnings and other pertinent weather information directly from weather offices to the general public, mariners, safety officials, news media, utility companies, schools, or anyone having need for up-to-the-minute information. Through a tone-alert device, specially equipped radio receivers can be demuted by the NOAA transmitter, thus affording a positive and immediate notice of warning to anyone having this equipment.

The NWWS[2] is a series of 75-wpm statewide and areawide circuits used to distribute consumer-oriented weather warnings, forecasts, and data from Weather Service Offices (WSO) to the mass news

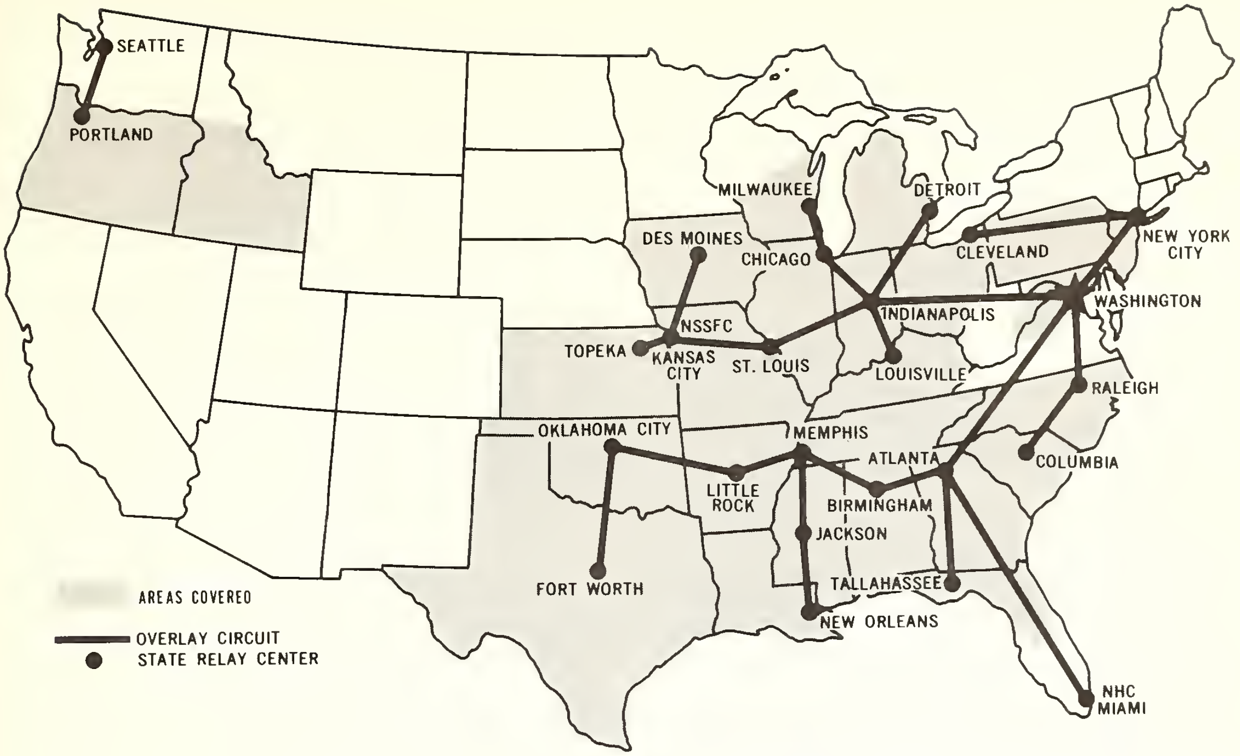

FIGURE 5.—NOAA Weather Wire Service (NWWS).

media for relay to the public and various specialized users. It incorporates the visual and audio capability to alert all users to critical incoming messages. The WSOs have direct entry on these circuits. The Service also includes three 100-wpm teletypewriter overlay-relay circuits which enable State Relay Centers to obtain and further distribute the required information from other States. The WSFOs furnish broad-scale information, and the WSOs enter local information. The NWWS is expanding and will eventually service approximately 5,000 radio stations, 600 television stations, and 1,700 newspapers in 3,000 cities and towns in the Nation. The mass media subscriber pays only for the use of a local line and equipment. Figure 5 shows those areas now covered by NWWS.

Many of these WSFOs and WSOs have been supplemented with specially trained personnel who provide weather information for aviation, agriculture, fire weather, and other specialized user groups. A few WSOs are operated solely to provide weather information for specialized users, as necessitated by technical or economic considerations. Additionally, the DOC has initiated a program with the objective of informing the public of disaster potential through close cooperation with State and local offices in those communities where these destructive forces of nature are likely.

The Department of Defense operates 428 weather service offices on land and aboard ship that furnish forecasting, briefing, climatological, and consultant services in support of military weapons systems, facilities, and installations. Defense mobile units provide weather support for maneuvers, exercises, and special military and contingency operations.

FLIGHT SERVICE STATIONS (FSS)

The FAA network of 332 FSSs provides weather information to aviation interests at civil airports. Many of these FSS facilities also furnish weather-briefing services by telephone to pilots at smaller airports that have no other weather information source. Some airports have both an FAA-FSS and a NOAA-WSO; the FSS personnel handle routine briefings, and the WSO takes requests requiring a meteorologist.

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[2] The NWWS was previously reported under "Communications." It will henceforth be included under "Dissemination."

Table 21.—Agency operational costs, by type of dissemination to users

[Thousands of dollars]

Agency	Weather Service Offices		Flight Service Stations		Coastal Warning Stations		Voice telescriber and television		Other		Totals	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
AEC	109	130	......	......	......	......	......	......	......	......	109	130
Commerce	17,417	18,487	......	......	......	......	686	1,086	......	......	18,103	19,573
Defense	30,059	27,598	813	804	247	295	409	418	3,268	3,179	34,796	32,244
EPA	......	......	......	......	......	......	......	......	50	100	50	100
NASA	......	......	......	......	......	......	1	1	134	169	135	170
Transportation	......	......	(5,638)	(6,851)	(50)	(50)	(6,996)	(7,512)	(150)	(400)	(12,834)	(14,813)
Coast Guard	......	......	......	......	50	50	145	150	150	400	345	600
FAA	......	......	5,638	6,851	......	......	6,851	7,362	......	......	12,489	14,213
Total	47,585	46,215	6,451	7,655	297	295	8,092	9,017	3,602	3,848	66,027	67,030

COASTAL WARNING SYSTEM

The Department of Commerce, Coast Guard, State and local governments, and private interests cooperate in a Coastal Warning System to warn pleasure boatmen and other marine interests that lack radio-receiving equipment of impending weather conditions on coastal and inland waters. More than 490 flag or light displays are operated along the seacoasts, the shores of the Great Lakes, and on the inland waterways.

VOICE, TELESCRIBER, AND TELEVISION

Voice communications systems have a major role in meteorological services. Weather information is disseminated to the general public through telephones, telephone-answering recorders, and very high frequency/frequency modulation (VHF/FM) continuous broadcasting. Use of recorders for distributing weather information to the public, marine, and other specialized groups is on the increase; recorders allow a growing number of users to be served at minimum expense. For aviation users the FAA broadcasts recorded weather observations, and the National Weather Service of NOAA provides forecasts and warnings. The Department of Commerce is increasing its use of continuous VHF/FM broadcasts to distribute forecasts and warnings to the general public as part of the Natural Disaster Warning System. The Coast Guard operates a number of radio stations to disseminate forecasts and warnings for coastal and offshore areas. The FM radio systems are also being used as emergency communications to link essential Commerce facilities with mass news media and public agencies in areas where a high incidence of hurricanes and severe storms frequently disrupts normal communications. The Department of Defense operates 106 two-way radio stations in the United States for direct voice contacts between forecasters and airborne pilots.

Telescriber systems are used at many civil and military airfields to disseminate observations, forecasts, and warnings to air traffic controllers, aircraft operations offices, and other users. Closed-circuit television is used extensively by Defense to distribute weather information and to brief pilots and operational control personnel on the weather.

Program Changes for Fiscal Year 1974

The following paragraphs highlight the program changes for the entire dissemination function, and table 21 lists the operational costs, by agency, for each of the categories.

The Department of Commerce, in FY 1974, will accelerate its efforts to provide timely forecasts and warnings and to improve individual and community preparedness for hazards. In partial fulfillment of its objectitve of the capability to alert 95 percent of the populace, also a common requirement, Commerce plans to provide or augment the VHF/FM staff at seven locations at $300,000 and to lease additional telephone answering devices to disseminate recorded weather information at $100,000. Although the program to extend the NWWS was reduced in FY 1973 to $240,000, an increase of $550,000 is planned for FY 1974 to extend the service to additional States. In its related program to improve community preparedness, Commerce is adding community preparedness specialists at 14 WSFOs throughout the tornado and hurricane belts of the U.S. at $520,000. The program of providing climatologists for the States is being eliminated with a saving of $110,000 in FY 1973 and $1,218,000 for the 12 months of FY 1974.

The U.S. Coast Guard, in FY 1974, will continue efforts to improve its service to the boating public with the development of passive dissemination systems for broadcasting environmental information at $400,000. Purchase of five tactical weather systems by Defense in FY 1973 for an additional $700,000 completes this program, so Defense reflects an offsetting $3,600,000 reduction in FY 1974.

The FAA, in FY 1973, initiated the En Route Flight Advisory Service (EWAS) and established four outlets to provide this service. This and pay raises account for much of the increases reflected over that previously reported. In FY 1974, the FAA plans to establish 21 additional En Route Flight Advisory Service outlets at $541,000, and to provide for an additional 1.6 million pilot briefings at a cost of $1,213,000.

GENERAL AGENCY SUPPORT

Description

General agency support covers four activities—internal support, training, maintenance, and management above operating level—which agencies must sustain to operate effective meteorological service programs.

INTERNAL SUPPORT

General mission-related activities in support of meteorological operations within an agency are necessary for providing service to users. These activities include the following types of programs:

- Engineering support for planning, preparing technical specifications, surveying equipment sites for suitability, accepting and installing new equipment, and calibrating, maintaining, and repairing commissioned equipment systems.
- Scientific studies, services, and consultations to determine the feasibility of new programs and to increase the effectiveness of current programs.
- Quality control of products to assure the maintenance of standards for accuracy and productivity.
- Office quarters and employee housing at remote-area locations.

TRAINING

Training in weather observations, communications, maintenance, and similar technician-level skills is accomplished at schools operated by Federal agencies; professional-level training is obtained by attendance at accredited colleges and universities. Training costs include instructor and student pay, equipment, travel, books, and tuition.

The major portion of the Federal training effort is by Department of Defense agencies to meet their military requirements. Technician-level training is conducted at Defense schools. The U.S. Air Force and U.S. Army use colleges and universities for both basic and advanced training of their professional-level personnel. The U.S. Navy, however, provides professional-level education leading to baccalaureate and advanced degrees at its Postgraduate School in Monterey and uses civilian colleges or universities primarily for special or doctoral degree work. Some personnel trained under these Defense programs are employed by civilian meteorological agencies after leaving the military service. This action significantly reduces the need for meteorological training programs in other Federal agencies.

The Department of Commerce operates the NOAA National Weather Service (NWS) Technical Training Center at Kansas City for training meteorological technicians and electronics and facilities maintenance technicians. A refresher course at the professional level for meteorologists is given at NWS Headquarters in Silver Spring, Md. Other professional-level training is available through colleges and universities or in programs operated by other Federal agencies. The U.S. Coast Guard operates a Marine Science Technician (MST) Class-A School for basic training in its MST rating. Approximately 40 percent of this curriculum is devoted to meteorology, replacing the basic training obtained through the Navy's Aerographers Mate schools. The FAA Academy at Oklahoma City trains that agency's personnel in the meteorology required for air traffic control, weather observations, En Route Flight Advisory Service, flight operations, and in communications equipment maintenance. The Environmental Protection Agency conducts air pollution meteorology training programs for professionals in air pollution control at the Federal, State, and local levels.

Some economies in training are being realized through use of one agency's training program by another, avoiding duplicating facilities and staffs. Also, Commerce is effecting additional economies through home-study courses, utilizing both commercial correspondence and in-house-developed programs to supplement formal residence courses.

MAINTENANCE

Maintenance is performed at central overhaul facilities and at regional and local shops. Most maintenance is accomplished locally where emphasis is placed on preventive maintenance and swift emergency actions to restore vital facilities to operation.

Table 22.—Agency operational costs, by type of general agency support

[Thousands of dollars]

Agency	Internal support		Training		Maintenance		Management above operating level		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 73	FY 73	FY 74
AEC	438	518	157	185	16	19	62	73	673	795
Commerce	4,246	4,469	1,058	1,108	13,291	13,622	15,459	15,715	34,054	34,914
Defense	4,710	4,428	20,383	18,728	10,949	12,469	10,536	10,294	46,578	45,919
EPA	400	200	......	......	......	......	......	......	400	200
NASA	96	118	......	38	388	369	117	59	601	584
Transportation	(2,532)	(2,672)	(481)	(582)	(3,756)	(4,005)	(2,997)	(3,197)	(9,766)	(10,456)
Coast Guard	......	......	153	153	......	......	56	56	209	209
FAA	2,532	2,672	328	429	3,756	4,005	2,941	3,141	9,557	10,247
Total	12,422	12,405	22,079	20,641	28,400	30,484	29,171	29,338	92,072	92,868

The Departments of Defense and Commerce operate central overhaul facilities for major repair or rebuilding on entire items or major components of equipment. Regional maintenance facilities are supported by Defense to furnish technical assistance to local maintenance shops to perform preventive and corrective maintenance that is beyond the capability of the local shops.

MANAGEMENT ABOVE OPERATING LEVEL

Management, supervision, administration, and logistic support are considered basic to units at the operating level; however, a certain amount of executive management, administration, and logistic support must come from higher echelons. In general, the management above operating level of units is confined to civil agency headquarters, to civil regional offices, and to similar headquarters in the military agencies.

Program Changes for Fiscal Year 1974

The following paragraphs highlight the program changes for the general agency support function, and table 22 lists the operational costs, by agency, for each of the categories for FY 1973 and FY 1974.

The Department of Commerce, in FY 1973, reduced and eliminated some program changes reflected in the previous Plan. New construction was reduced from $1,005,000 to $470,000; costs for staff to maintain the physical plant were reduced from $525,000 to $200,000; costs for replacement of outmoded equipment were reduced from $500,000 to $350,000; costs for spare parts were reduced from 709,000 to $350,000; and the cost of rehabilitating the facilities at Kodiak, Alaska, were deleted. For FY 1974 the Department plans to accelerate activities to provide emergency backup facilities. To assure continuity of operations during commercial power and communications outages, it is purchasing four additional emergency power generators at $100,000. This internal support item contributes to the common requirement of providing forecasts and warning services. In the maintenance area, Commerce is programming the construction of new observatories and the relocation of others where required at $160,000.

The FAA, in FY 1973, experienced significant reductions in their training program which were largely offset with increases due to revised requirements for internal and management support staffs. General increases in FY 1974, in addition to pay raises, are due to increased maintenance requirements for five additional RVRs in the amount of $249,000.

Within the Department of Defense, the Army, in FY 1973, expanded the activities of its Field Artillery School at Fort Sill, Okla., to the extent of $266,000. The Air Force reduction in travel and expendables for maintenance in FY 1973 reflects a saving of $569,000. In FY 1974, increased personnel costs for maintenance because of revised standards will amount to $1,600,000. Nevertheless, overall reduction in personnel and reduced training in maintenance show a reduction of $1,845,000, and continued reduction in weather wings and Headquarters Air Weather Service show a reduction of $252,000.

Weather Satellites

INTRODUCTION

The satellite, as stated earlier, continues its increasingly important observational role of measuring the atmosphere. It provides an ever-increasing amount of information required to produce more accurate weather analyses and forecasts, more complete and timely storm warnings, and better oceanographic forecasts. This section describes the meteorological satellite system now in operation, the applications to meteorological service, and the operational and research plans for service improvement. Detailed information on these aspects of the meteorological satellite system will be found in the *Federal Plan for Meteorological Data from Satellites.*

NATIONAL OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM

The Department of Commerce, through the National Environmental Satellite Service (NESS) of NOAA, is the agency responsible for a national operational environmental satellite system. Thus the Department is charged with operating and improving the system to meet the coordinated requirements of all Federal agencies.

The system is based on space technology developed by NASA, which also procures and launches spacecraft according to Commerce specifications and is reimbursed with Commerce funds. The meteorological objectives of the operational system are:

- Viewing the atmosphere regularly and reliably on a global basis, day and night, with direct readout to local ground stations within radio range of the satellite.
- Continuous viewing of weather features and collecting and relaying environmental data from remote platforms such as buoys, ships, automatic stations, aircraft, and balloons.
- Sounding the atmosphere regularly and reliably on a global basis and providing quantitative inputs to numerical weather prediction.
- Applying meteorological satellite data to improving weather services.

The operational system consists of flight programs directed to the above objectives, Command and Data Acquisition (CDA) stations and a Satellite Operations Control Center through which satellites are controlled and data are acquired, facilities for the processing and analyzing of satellite products, and laboratories for satellite sensor experiments and developing applications of satellite data. Within the conterminous United States some direct readout and processed products are distributed to users over facsimile networks.

Flight Programs

The Improved TIROS (Television Infrared Observation Satellite) Operational Satellite (ITOS) has replaced the original TIROS Operational Satellite (TOS) which provided daytime global viewing and direct readout to local ground stations without interruption since February 1966. The ITOS system is shown in figure 6.

The prototype ITOS satellite, funded by NASA and designated as TIROS M, was launched on January 23, 1970, as ITOS 1. NOAA 1—the first operational ITOS spacecraft—was launched on December 11, 1970, to provide full redundancy in orbit and assure continuity of ITOS functions. However, both the prototype and the first operational spacecraft failed early in FY 1972 because of malfunctions in the stabilization and control assemblies. The replacement spacecraft, ITOS B, launched on October 21, 1971, failed to orbit, the result of problems in the second stage of the launch vehicle. ITOS D, designated NOAA 2, was successfully launched on October 15, 1972. NOAA 2, although similar in appearance to the earlier ITOS satellites, is the first operational environmental satellite in the series to fly with no onboard cameras, relying entirely on scanning radiometers for imagery, and is the first operational satellite to carry a sensor to obtain vertical temperature profile soundings of the atmosphere on a near-global basis.

In the interval following the loss of ITOS 1 and NOAA 1, a spacecraft of the older TOS

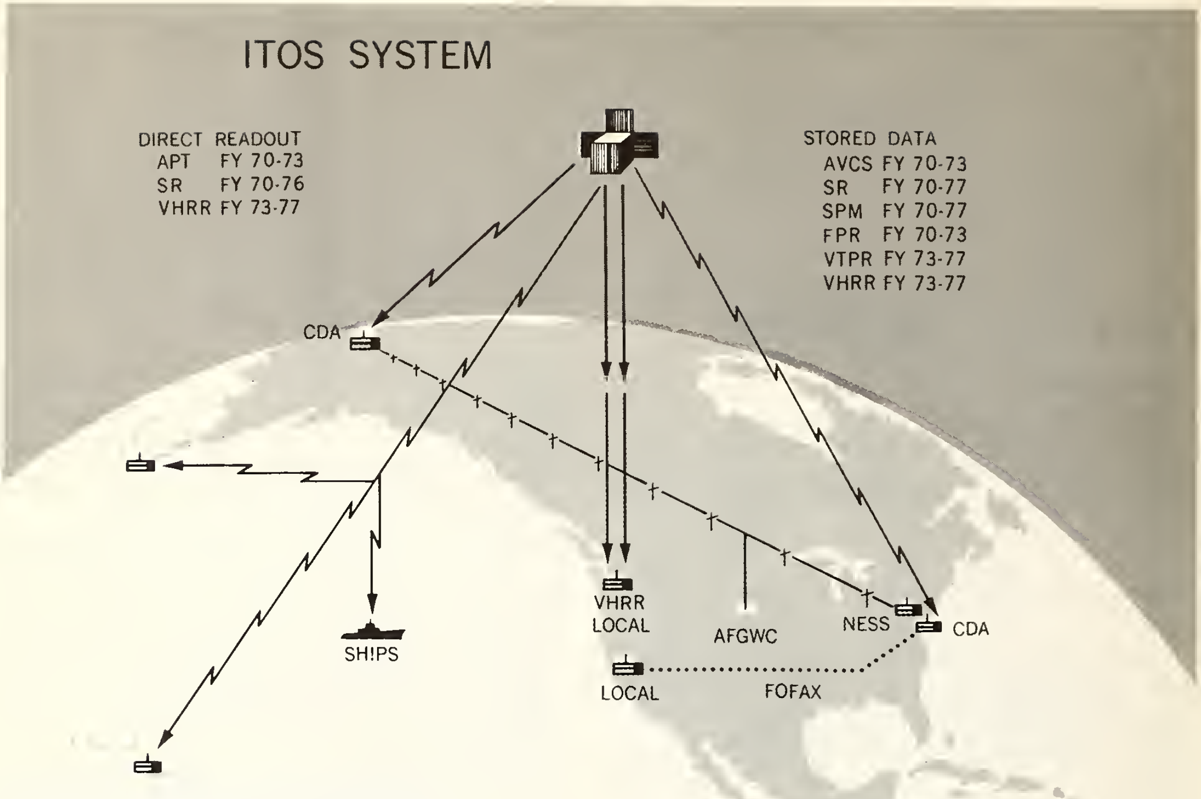

FIGURE 6.—Schematic of ITOS System.

series, the Environmental Survey Satellite (ESSA) 8, continued to provide automatic picture transmission (APT), while the ESSA 9 spacecraft provided advanced vidicon camera system (AVCS) daytime service.

NOAA continued real-time acquisition and use of data from the NASA research satellites—Applications Technology Satellites (ATS) 1 and 3 in geostationary orbits over the eastern Pacific and western Atlantic Oceans. Video data has not been obtained from ATS 1 since October 15, 1972, because of onboard circuit problems.

Tables 25 and 26 and the end of this section summarize the first decade of meteorological satellite flights and list flights launched or planned, indicating the sensors and functions provided, for the period 1970-74.

Data Applications

Global stored data are received at CDA stations, processed into products, and distributed for use at the three primary analysis and forecasting centers—the NOAA National Meteorological Center (NMC), the Air Force Global Weather Central (AFGWC), and the Navy Fleet Numerical Weather Central. The processed products are also distributed to other NOAA and Defense units by means of facsimile landlines. The direct readout system provides regional observations in real time for detailed analysis and for use by other forecast centers and services throughout the world.

Techniques to derive quantitative information from satellite data, needed for worldwide numerical weather forecasting, continue to improve. Techniques now in use include computer-derived cloud motion vectors, improved methods for analyzing and forecasting tropical cyclone intensities, and estimates of moisture content and circulation patterns—all derived from cloud patterns. Vertical temperature profiles of the atmosphere are routinely prepared from NOAA 2 Vertical Temperature Profile Radiometer data and integrated into numerical weather forecasting programs at the National Meteorological Center.

Time-sequence movie loops, prepared from the geostationary ATS 1 and 3 photographs (until the loss of ATS 1 picture capability) and based on near-continuous coverage from the geostationary satellite, have been integrated into NMC, National Hurricane Center (NHC), and National Severe Storms Forecast Center (NSSFC) operations and development programs.

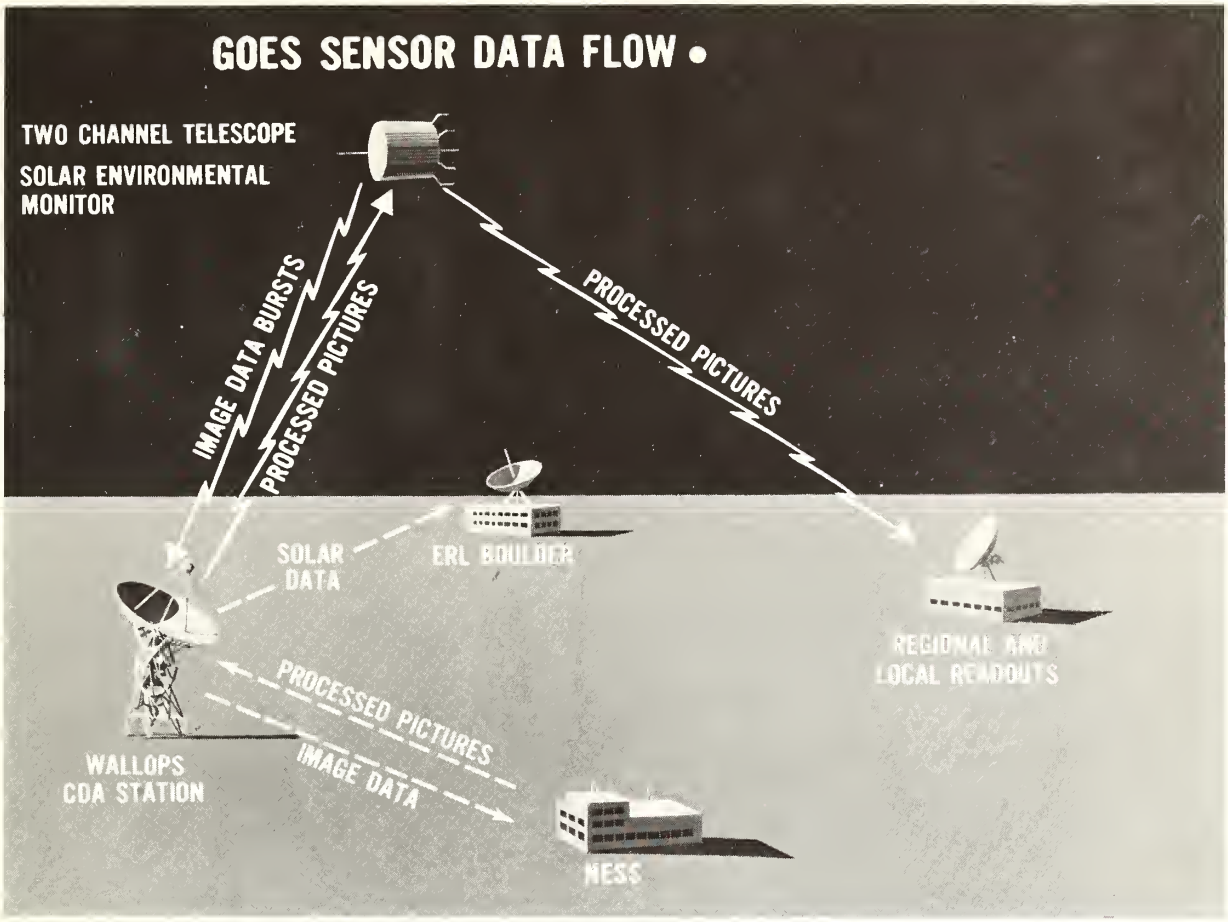

FIGURE 7.—Schematic of GOES sensor data flow.

Ways to determine sea-ice distribution and sea-surface temperature continue to be improved; for example, satellite imagery shows characteristic seasonal changes in polar ice cover. Infrared data show that some ice areas are persistently warmer than others, suggesting thinner ice in the warm regions.

Development of methods to enhance display of thermal patterns to depict Gulf Stream eddies and meanders has continued, and tracking of these eddies has resumed following the launch of NOAA 2. Mesoscale prediction techniques were developed for summer thunderstorms using satellite photographs; mini-squall lines expanding from convective storms were monitored using animated picture sequences; and a 4-year circulation climatology of the tropics was prepared using winds derived from ATS photographs. Techniques for determining thaw conditions of snowfields using comparative analysis of observations in the visible and near-infrared spectra have been verified with data from NASA's Earth Resources Technology Satellite, and satellite infrared measurements have been useful for mapping snow cover extent.

OPERATIONAL PLAN

Spacecraft and Launching

The ITOS system will be maintained with launches as needed, projected at about 1-year intervals. ITOS E is scheduled for launch in the first quarter of FY 1974; ITOS F is available as a backup.

Satellites of this series, beginning with NOAA 2, include a capability for obtaining vertical temperature and moisture profiles of the atmosphere. Addition of the Vertical Temperature Profile Radiometer (VTPR) system completes the first operational system for sounding the atmosphere twice daily on a global basis, a major objective of the national operational environmental satellite program. The Very High Resolution Radiometer (VHRR) system provides high-resolution imagery (0.5 n.mi. under satellite track). The VHRR operates mainly as a unique local readout subsystem

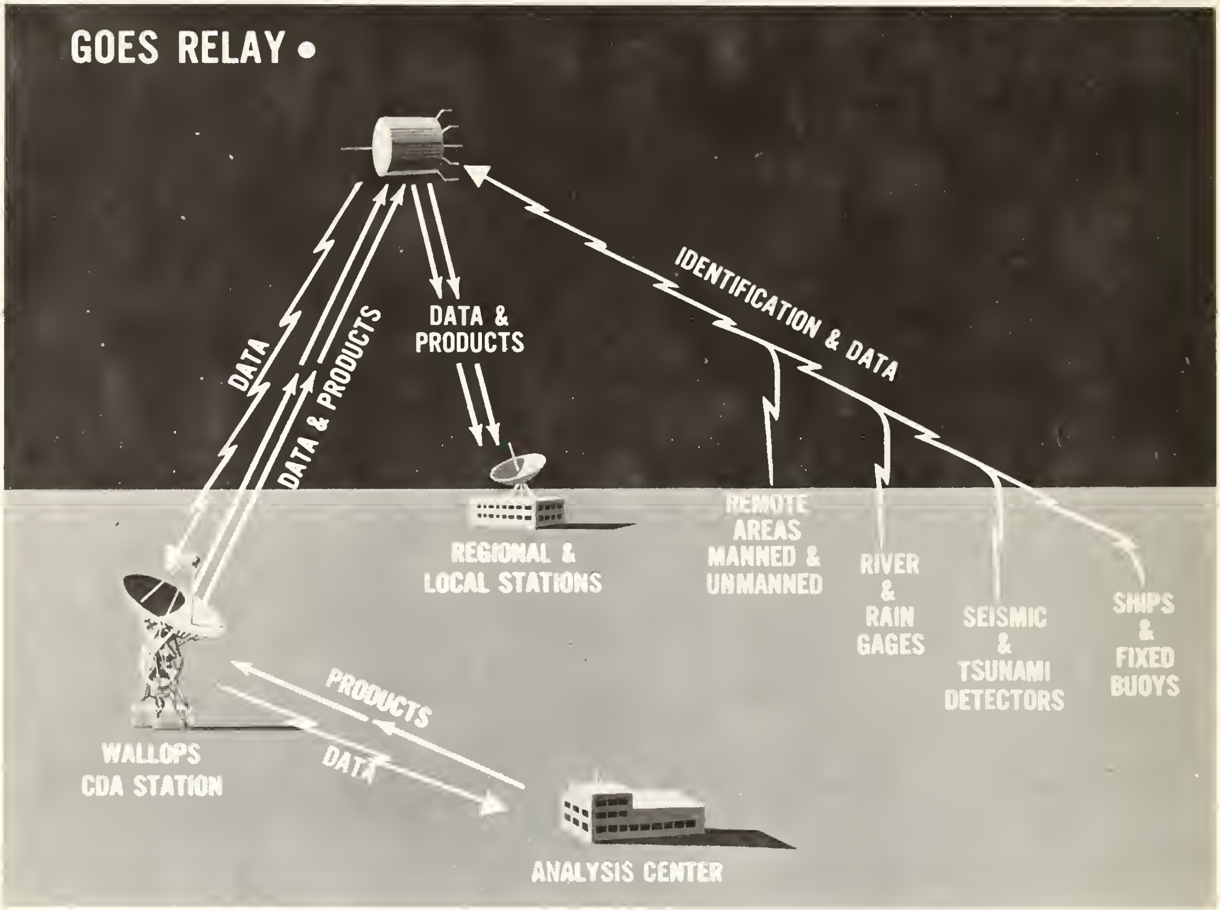

FIGURE 8.—Schematic of GOES relay system.

to specially equipped locations, with limited high-resolution storage capacity for data from selected remote areas. The vidicon camera systems in use on the earlier ITOS have been discontinued; their daytime viewing is performed by the combined day and night viewing and temperature sensing Scanning Radiometer (SR). The primary sensor complement—SR, VHRR, and VTPR—is expected to continue on the polar-orbiting satellites into FY 1977. The APT service will continue with the signal provided by the SR; day and night service is available from the SR which observes in both the visible and infrared spectra. To receive SR data, a conventional APT ground-station recorder must be modified. The details of the modification vary with the manufacturer and type of recorder. A Solar Proton Monitor (SPM) is carried as a secondary sensor.

The ITOS series of operational environmental satellites will be replaced by a new series in the late 1970s. The TIROS N series spacecraft will have the capacity to receive advanced oceanographic and hydrologic sensors to be developed by NASA.

The initial capability for near-continuous day and night cloud viewing and data collection-and-relay will be established with launch of the Synchronous Meteorological Satellite (SMS), the SMS A and B—the NASA-funded prototypes for the Geostationary Operational Environmental Satellite (GOES). NOAA is funding the followup operational GOES spacecraft to maintain the GOES system. The SMS/GOES will carry the Visual and Infrared Spin-Scan Radiometer (VISSR) system, providing nearly continuous observation of cloud cover day and night and measurements of cloud-top and surface temperatures. Wind information will be derived from cloud motions. A capability will be included for collecting raw data from surface platforms (fig. 7) and relay of processed data from analysis centers to remote-receiver stations (fig. 8). A Space Environment Monitor will also be carried.

The first operational prototype, the SMS A, is

Table 23.—Agency operational weather satellite program costs, by function

[Thousands of dollars]

Agency	Spacecraft and launching		Command and data acquisition		Data processing		Technical management and support		Total	
	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce..........	14,359	25,976	5,805	6,308	10,044	13,251	4,262	4,485	34,470	50,020
Defense............	......	......	(1,196)	(1,182)	(1,759)	(4,058)	(324)	(410)	(3,279)	(5,650)
Navy...............	......	......	992	1,022	1,122	2,754	324	410	2,438	4,186
Air Force..........	......	......	204	160	637	1,304	......	......	841	1,464
Total...............	14,359	25,976	7,001	7,490	11,803	17,309	4,586	4,895	37,749	55,670

scheduled for launch about October 1973 and will be located over the Equator at about longitude 100°W. This location will afford near-continuous high-resolution surveillance of an area 6,500 nautical miles in diameter beneath the spacecraft and relay of data over an area of about 9,500 nautical miles in diameter. With the launch of SMS B, the second operational prototype, and the subsequent replacement GOES satellites in later years, it is planned to maintain two satellites in geostationary orbit, providing near-continuous viewing and data collection-and-relay over a major part of the Western Hemisphere between latitudes 55°N and 55°S.

NOAA plans for FY 1974 funding of spacecraft programs include the accrued costs for constructing the ITOS G and H spacecraft and beginning procurement of the ITOS I spacecraft and parts for a J spacecraft; completing the GOES A spacecraft and beginning procurement of the GOES B and C; and starting procurement of the sensors for the TIROS N series spacecraft. Fiscal Year 1974 launch requirements include funds for completing the ITOS F and G launch vehicles, launch service for ITOS G, completion of the GOES A launch vehicle, and launch service for GOES A.

Command and Data Acquisition (CDA)

The NOAA Command and Data Acquisition (CDA) stations, located at Wallops Station, Va., and Gilmore, Alaska, have been equipped and staffed to maintain and operate previously approved programs and to proceed with planned program improvements. Equipment and staff are complete for the ongoing ITOS program and are planned to be for the one-satellite operational GOES system by the beginning of FY 1974. Equipment required for the operational two-satellite GOES system is being procured and will be installed to make the system operational in late FY 1974. Procurement of long-lead time unique ground equipment for the TIROS N series system, begun in FY 1973, will continue. Increased maintenance and operating staff for the two-satellite GOES system will be located at the Wallops CDA and the Suitland, Md., Satellite Operational Control Center.

Defense is upgrading a number of APT ground stations to receive weather facsimile (WEFAX)-type transmissions through GOES and to secure more effective use of the ITOS APT service. The detailed description of APT system operations is contained in the *Federal Plan for Meteorological Data from Satellites.*

Data Processing

NESS and AFGWC receive the stored scanning radiometer data from the ITOS spacecraft for computer processing. NESS uses the NOAA central computers, smaller computers, and manual techniques to convert observational data into forms suitable for immediate use in analysis and forecasting routines and for subsequent research and climatological use.

For FY 1974 the Department of Commerce needs additional staff to handle new data from the operational two-satellite GOES system and to deduce wind by automated techniques using the GOES data. The winds obtained will be integrated into the quantitative data input to the numerical weather forecasting routines. The requested increase affords a complete study of NESS data handling and processing requirements to determine the effect of digital data processing on network control, data scheduling, and communications for the TIROS N series.

Included in the request are the final increments of the professional and technical staff needed to operate and maintain the NESS Satellite Field Services Stations at Miami, Fla., Washington, D.C., Kansas City, Mo., San Francisco, Calif., and Honolulu, Hawaii. The Air Force plans to operate a similar facility at its Global Weather Central, Offutt AFB. These increases enable development of meso-

Table 24.—Agency supporting research weather satellite program funding, by function

[Thousands of dollars]

	Satellite flight projects		Satellite instruments and experiments		Spacecraft technology and associated ground equipment		Satellite data analysis and applications		Total	
Agency	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74	FY 73	FY 74
Commerce	......	......	1,362	1,362	......	......	1,322	1,947	2,684	3,309
Defense	......	......	......	......	......	......	(2,357)	(2,335)	(3,155)	(2,885)
Air Force	......	......	......	......	......	......	315	315	315	315
Army	......	......	......	......	......	......	1,842	1,820	1,842	1,820
Navy	......	......	798	550	......	......	200	200	998	750
NASA	20,707	15,831	7,518	11,905	475	525	978	2,035	29,678	30,296
Total	20,707	15,831	9,678	13,817	475	525	4,657	6,317	35,517	36,490

scale forecast techniques and models using geostationary satellite data, field experiments, and test and evaluation of equipment to improve the Satellite Field Services Station operation.

Special analysis support to marine resources and oceanographic and hydrologic services will be expanded. The effort, begun in FY 1973, to extract quantitative data from satellite observations to apply to the problems of reducing operational forecast error and extending the range of weather forecasts also will be expanded. Before FY 1973 major NESS data processing needs included only ITOS data. GOES data will require a larger quantity and variety of satellite data processing, hence more funds and staff for expanding the NOAA computer facility.

Technical Management and Engineering

Initial technical management and engineering support by NASA for the TIROS N series program require an increase of $200,000. The balance of the NOAA increase in this area is for NOAA staff to provide systems engineering and integration support to the TIROS N series and GOES data collection system and to begin studies on a disaster warning satellite.

Table 23 lists the agency operational weather satellite program costs, by function, for FY 1973 and FY 1974.

SUPPORTING RESEARCH

Meteorological research conducted by NASA and the Departments of Commerce and Defense provides the data utilization techniques necessary to meet these agencies' major long-term objectives for a coordinated meteorological satellite program.

Global-viewing, the first major objective, was largely achieved with the TIROS M and ITOS spacecraft. Efforts continue toward improved resolution, location, and display. Attention is also being given to developing methods for measuring additional environmental properties, to solving data and product distribution problems, and to improving ground stations.

The second major objective includes both continuous viewing and collecting and relaying meteorological data from instrumented platforms such as buoys, ships, automatic stations, aircraft, and balloons. NASA conducts experiments in support of this objective with its Nimbus and ATS series and is funding the SMS prototypes for the GOES operational spacecraft.

The third major objective—regular and reliable atmospheric sounding on a global basis and quantitative inputs to numerical weather prediction—is also being supported by NASA in experiments on the Nimbus series. Research and development for the third major objective are emphasized in NASA's Nimbus program and in NOAA's program to develop sensing techniques. After a year in orbit and successfully completing its mission, Nimbus 4 suffered a failure of the rate measurement package, which unstabilized the yaw. Nevertheless, useful data continue to be obtained from all but three of the newer instruments—the Filter Wedge Spectrometer (FWS), the Temperature and Humidity Infrared Radiometer (THIR), and the Infrared Interferometer-Spectrometer.

Commerce and Defense conduct a wide variety of studies on the applications of meteorological satellite data to improve services—the fourth major objective. Efforts will be directed to developing new methods for using satellite data in environmental analysis and forecasting. The radiative and optical properties of atmospheric constituents are being studied to aid the design of satellite-borne sensors and the interpretation of data from them. Special attention is given to interpreting and validating new data acquired by operational and research satellites and to applying these data as inputs to numerical analysis and forecasting.

Meteorological satellite research is described in detail in the *Federal Plan for Meteorological Data from Satellites,* in particular the description of the polar-orbiting satellites Nimbus E and F, and TIROS N, the geosynchronous meteorological satellite, and the description of developmental applications.

Table 24 lists the agency funding the research, by function, for the weather satellite program.

Table 25.—Summary of meteorological satellite flights, 1960-69

Satellite	Purpose	Launch Date	Operations ceased date
TIROS I	Research	4/ 1/60	6/15/60
TIROS II	Research	11/23/60	2/ 7/61
TIROS III	Research	7/12/61	10/30/61
TIROS IV	Research	2/ 8/62	6/12/62
TIROS V	Research	6/19/62	5/ 5/63
TIROS VI	Research	9/18/62	10/11/63
TIROS VII	Research	6/19/63	2/ 3/66
TIROS VIII	Research	12/21/63	1/22/66
Nimbus I	Research	8/28/64	9/23/64
TIROS IX	Research	1/22/65	2/15/67
TIROS X	Research	7/ 1/65	7/31/66
ESSA 1	Operational	2/ 3/66	5/ 8/67
ESSA 2	Operational	2/28/66	10/16/70
Nimbus 2	Research	5/15/66	11/15/66
ESSA 3	Operational	10/ 2/66	10/19/68
ATS 1	Research	12/ 6/66	—
ESSA 4	Operational	1/26/67	6/19/67
ATS 2	Research	4/ 5/67	(1)
ESSA 5	Operational	4/20/67	2/20/70
ATS 3	Research	11/ 5/67	—
ESSA 6	Operational	11/10/67	11/ 4/69
ESSA 7	Operational	8/16/68	7/19/69
ESSA 8	Operational	12/15/68	—
ESSA 9	Operational	2/26/69	—
Nimbus 3	Research	4/14/69	9/25/70

[1] Unstable altitude; data not useful.

Table 26.—Meteorological satellite flights and functions, 1970-74

Satellite	Purpose [1]	Launch date	Orbit	Instruments and functions [2]	Remarks
ITOS 1	R/O	1/23/70	Sun Synch. 790 n. mi.	2 AVCS, 2 APT, 2 SR; OMNI, SPM.	Ceased operations June 1971.
Nimbus 4	R	4/ 8/70	Sun Synch. 600 n. mi.	IDCS, THIR; IRIS, SIRS, SCR, FWS; IRLS; BUV, MUSE.	THIR, FWS and IRIS not operable.
NOAA 1	O	12/11/70	Sun Synch. 790 n. mi.	2 AVCS, 2 APT, 2 SR; OMNI, SPM.	Ceased operations August 1971.
ITOS B	O	10/21/71	Sun Synch. 790 n. mi.	2 AVCS, 2 APT, 2 SR; OMNI, SPM.	Failed to orbit.
ITOS C	O	3/ /72	Sun Synch. 790 n. mi.	2 AVCS, 2 APT, 2 SR; OMNI, SPM.	When no longer needed as backup, ITOSC will probably be retrofitted with advanced sensors.
NOAA 2	O	10/15/72	Sun Synch. 790 n. mi.	2 SR, 2 VHRR; 2 VTPR; OMNI, SPM.	
ITOS E	O		Sun Synch. 790 n. mi.	2 SR, 2 VHRR; 2 VTPR; OMNI, SPM.	Backup to NOAA 2.
SMS A	R/O	10/ /73	Geo. Synch. 19,300 n. mi.	VISSR; DCDR; SEM.	
Nimbus 5	R	12/12/72	Sun Synch. 600 n. mi.	THIR, ESMR; ITPR, SCR, MWS; RDR; SCMR	
Nimbus F	R	6/ /74	Sun Synch. 600 n. mi.	THIR, ESMR, TWERLE, HIRS, SCAMS, LRIR, PMR, ERB, TDRE.	

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[1] R: Research
O: Operational
R/O: Operational prototype

[2] APT —Automatic Picture Transmission
AVCS —Advanced Vidicon Camera System (weather satellite)
BUV —Backscatter Ultraviolet Spectrometer
DCDR —Data Collection and Data Relay
ERB —Earth Radiation Budget
ESMR —Electrically Scanning Microwave Radiometer
FWS —Filter Wedge Spectrometer
HIRS —High Resolution Infrared Sounder
IDCS —Image Dissector Camera System
IRIS —Infrared Interferometer Spectrometer
IRLS —Interrogation, Recording, and Location System
ITPR —Infrared Temperature Profile (multichannel) Radiometer
LRIR —Limb Radiance Inversion Radiometer
MUSE —Monitor of Ultraviolet Solar Energy
MWS —Microwave Spectrometer
OMNI —Omnidirectional Radiometers
PMR —Pressure Modulated (carbon dioxide) Radiometer
RDR —Real-time Data Relay
SCAMS —Scanning Microwave Spectrometer
SCMR —Surface Composition Mapping Radiometer
SCR —Selective Chopper Radiometer
SEM —Solar Environment Monitor
SIRS —Satellite Infrared Spectrometer
SPM —Solar Proton Monitor
SR —Scanning Radiometer
TDRE —Tracking and Data Relay Experiment
THIR —Temperature-Humidity Infrared Radiometer
TWERLE —Tropical Wind, Energy Conversion, and Reference Level Experiment
VHRR —Very High Resolution Radiometer
VISSR —Visual and Infrared Spin-Scan Radiometer
VTPR —Vertical Temperature Profile Radiometer

Publications

The Federal Coordinator for Meteorological Services and Supporting Research has either prepared or is preparing a series of publications covering the broad spectrum of meteorological programs in the Federal Government. The following is a list of these publications and their status:

The Federal Plan for Meteorological Services and Supporting Research (Published annually)

World Weather Program Plan (Published annually)

National East Coast Winter Storms Operations Plan (Revised annually)

National Hurricane Operations Plan (Revised annually)

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